INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 85 **New York, April, 1927** *Number 4*

Two views showing front and back of the switchboard.

The switchboard contains one instrument panel, and nineteen three-section distribution panels, each controlling a building or group of buildings, and is built on three sides of a square. The transformer room is on the opposite side of the wall to the left.

Changing a Distribution System From D.C. to A.C. Service

By THOMAS C. HAYES

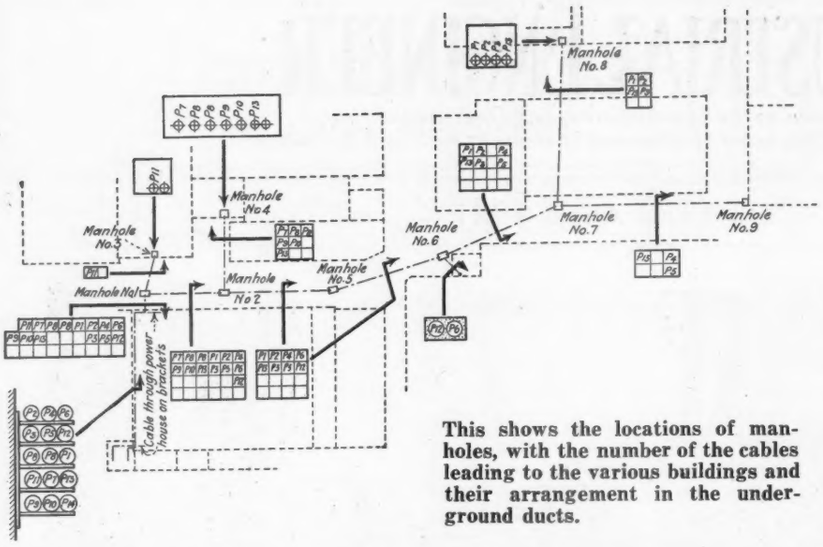
Chief Electrician, Wilson & Co., Union Stock Yards, Chicago, Ill.

OPERATING conditions in a meat-packing plant, due to the steam, condensate, water, ammonia, brine, and animal acid fumes to which the electrical equipment is exposed, are especially severe, particularly on direct-current motors. The plant of Wilson & Co., one of the packing houses grouped around the Union Stock Yards in Chicago, operated until about 3 years ago on 230-volt direct current, generated in our own power house and distributed over a two-wire system.

When I became connected with the Electrical Department in Chicago about 6 years ago, the cost of maintenance was very high due to the many burnouts and other interruptions to service resulting largely from the effect of moisture and the particular operating conditions. Interference with operation is a very serious problem in connection with the meat-packing industry.

Careful and thorough inspection of the motors, with particular attention where possible to wiping and cleaning armatures and providing protection against dripping moisture, reduced the motor failures to about three a month. However, the electrical equipment was old and was reaching the point where we would soon have to consider renewing a large part of it.

The advantages of alternating-current equipment with its lower cost of maintenance were investigated, together with the question of whether to buy or continue to generate our power. One of the factors considered when making the decision was that if we were to continue making our own power we would have to install practically an entirely new power plant, including boilers,



This shows the locations of manholes, with the number of the cables leading to the various buildings and their arrangement in the underground ducts.

stack and generating equipment. It was eventually decided to purchase power from the Commonwealth Edison Co. at 12,000 volts, 60 cycles, three phase, instead of putting in a new generating plant, and change all drives to 440-volt, alternating-current motors, with 110-volt, single-phase lighting circuits.

This, of course, required an entirely new distribution system. None of the old distribution systems, except an overhead transmission line, as will be mentioned later, could be used, because individual circuits had been added as necessary when additional equipment was installed—a common condition in many old plants.

The Wilson plant consists of 97 buildings covering 38 acres. Some of the buildings are ten stories high and contain the wide variety of lines of work in connection with a packing house.

Continuous operation of the plant is so vital that it was decided to have two sets of 12,000-volt feeders run into the plant. One of these connects directly with the Crawford Avenue generating station of the Commonwealth Edison Co., and the other with the Commonwealth Edison substation, located in the yards a few blocks away. This substation is connected with two of the other Commonwealth Edison generating stations through several direct lines.

If the lines from Crawford Avenue should fail for any reason, we still receive power through the substation, as this feeder is always in service. As with all Commonwealth Edison installations of this kind, we receive power on what is known as a loop system. Both sets of high-tension lines come into the plant under ground and are brought up to the transformer switchroom, which is on the second floor in a room adjoining the old power house. The concrete barriers and compartments for the equipment in the switching room were laid out and poured in a single slab with all openings cored out. It was not necessary to ream out a single hole, which makes us quite proud of the job. The open sides of the concrete switching compartments are closed with Transite asbestos board (Johns-Manville, Inc.) doors.

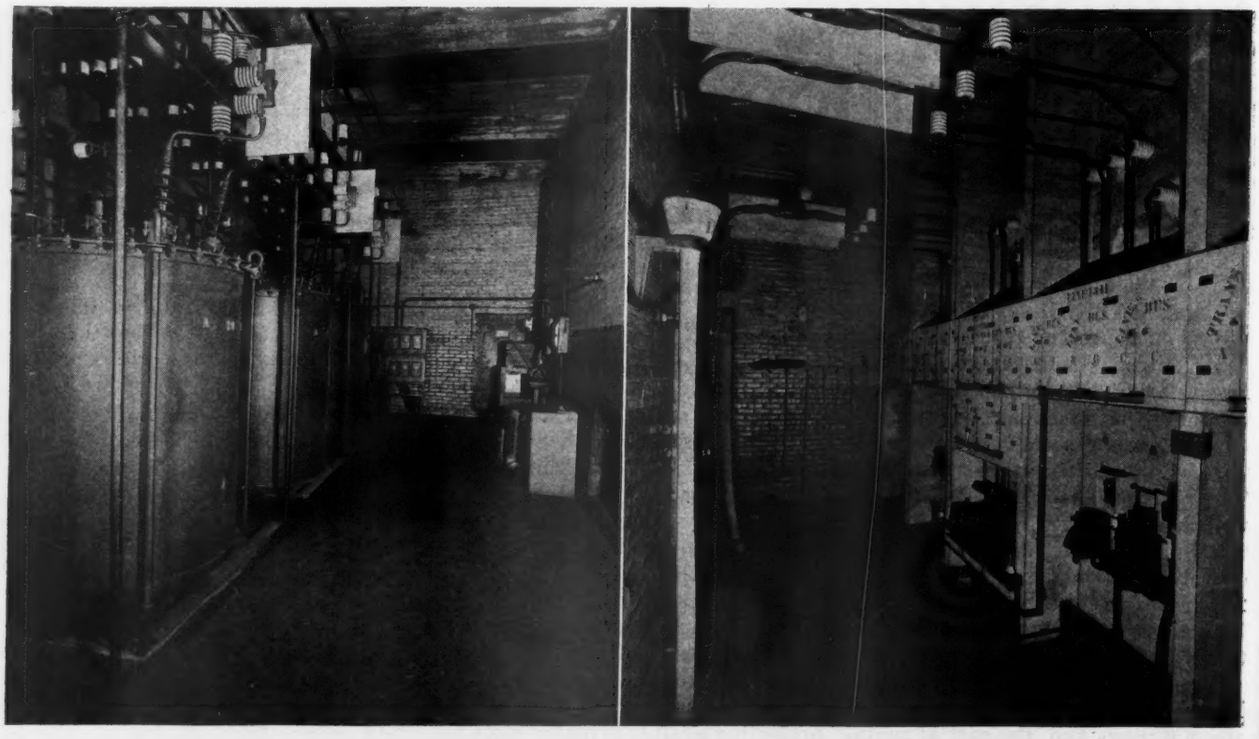
Each compartment is carefully marked by stenciling on the Transite front, as shown in an accompanying illustration.

An interior view of the transformer room.

Incoming power is stepped down from 12,000 volts to 440 volts by these 1,000-kva., single-phase Pittsburgh transformers. Direct current for the oil switches is supplied from a storage battery and motor-generator set.

Switching equipment for the incoming 12,000-volt lines.

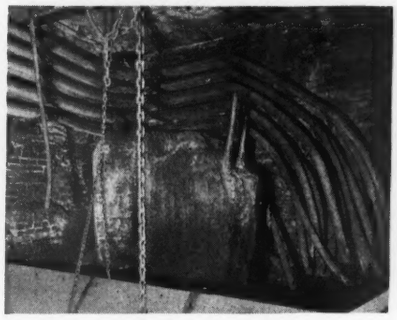
The incoming high-tension lines enter through the concrete ducts along the floor and extend up the wall at the left. The switching equipment is shown at the right. The front of the live sections is protected with Transite board.



The switching equipment on the incoming lines, the transformers and the switchboard are placed in three separate but adjoining rooms. Each has a separate locked entrance; the switchroom and transformer room, however, have a door between. Power is stepped down from the 12,000-volt, 60-cycle, three-phase incoming line to 440 volts by three 1,000-kva., single-phase, Pittsburgh water- and oil-cooled transformers. In case any transformer should fail, the two other transformers can be connected in open delta and will carry the load. Direct current for the Type F-10 Condit 25,000-volt oil switches is supplied from a Philco storage battery, which has its own motor-generator charging set. This set receives power from a 5-kva., 440/220/110-volt Pittsburgh pole-type transformer mounted on the floor in the transformer room. The lights for the switchroom are also supplied from this same pole-type transformer.

Transite board is mounted between the disconnect switches above the transformers, as may be seen in the illustration on page 150. The transformer room is ventilated by roof ventilators and louvres near the floor in the outside wall of the room.

The switching equipment on the incoming line is protected by phase-failure and reverse-phase relays and also has indicators to show which lines are working. An alarm system on both incoming lines and transformer breakers operates when any interruptions occur; the indicator shows which line is out. Another alarm system indicates when the transformer becomes too hot, due to water failure or other causes.



At the end of the tunnel the lead-covered cables enter the underground vitrified tile ducts leading to the different buildings.

The tunnel is about 100 ft. long and the cables are carried through it on cast-iron wall brackets. In all exposed locations the cables are wrapped with hemp rope and covered with cement.

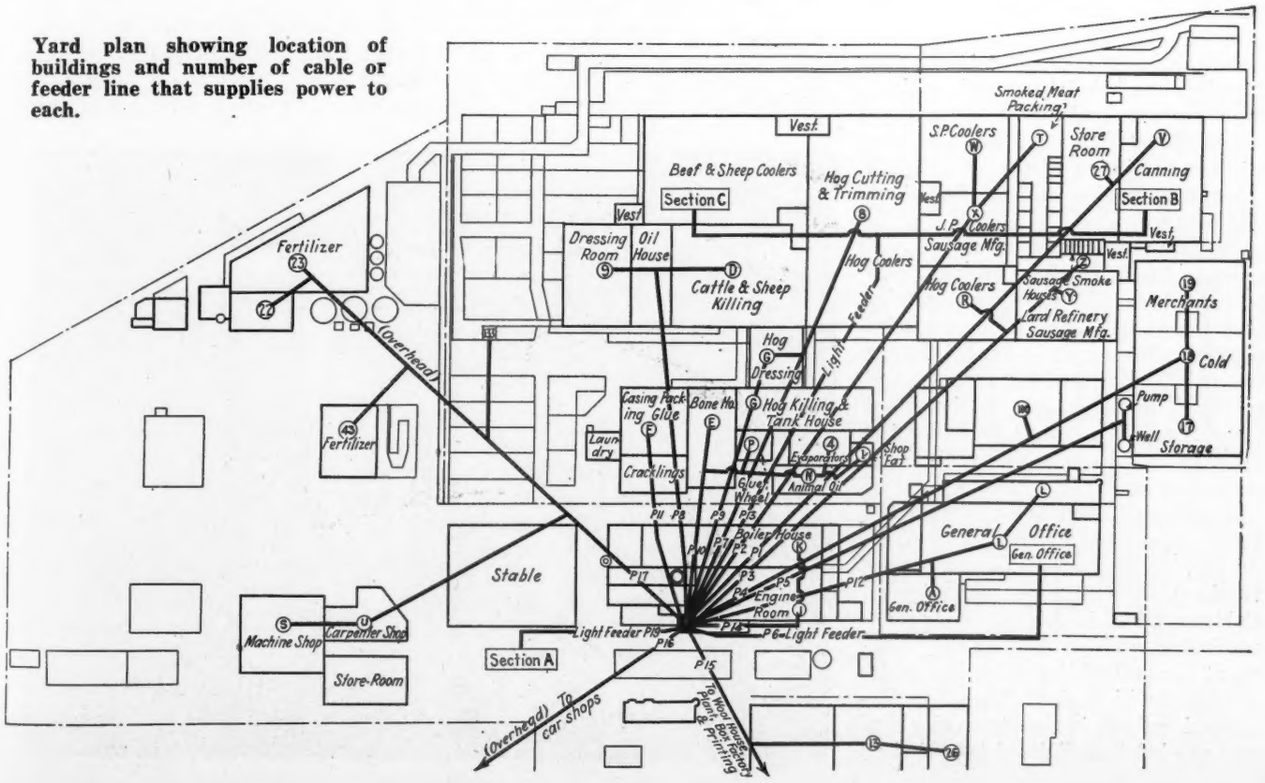
The switchboard is erected in a separate room adjoining the transformer room, but with no opening between them. The board has nineteen three-section slate panels, each feeding a building, department or group of equipment. Each panel carries a Weston indicating ammeter and a Condit Type E-4 oil circuit breaker either of 600-amp. or 800-amp. rating with oil dashpot overload relays with a current transformer on each outgoing leg of the three-phase line. An ammeter and an integrating wattmeter are connected into the main line. Also, a power factor meter is mounted on the instrument panel with provision made for plugging in any line to ascertain the power factor of that line. There is also a recording demand meter owned by the Commonwealth Edison Co.

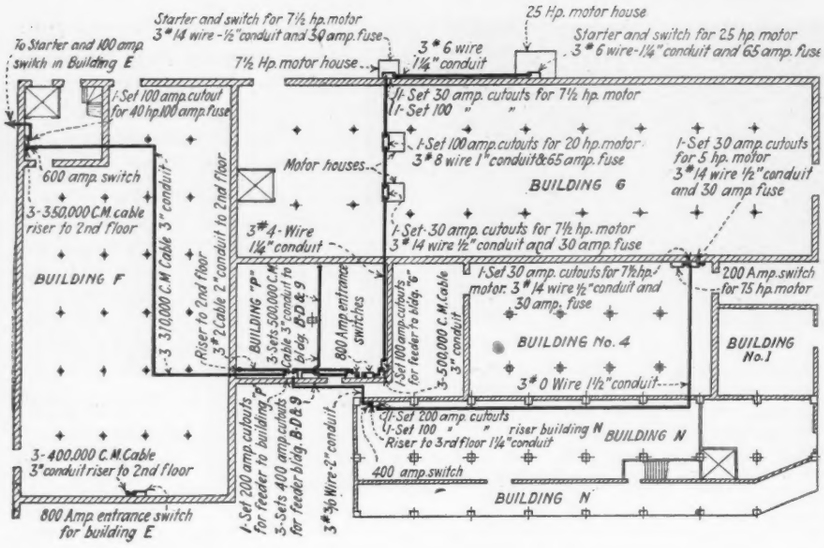
We are operating with a power factor of 83 to 85, which, we believe, is quite high for our industry. Our running load is about 3,400 amp. per phase, which is approximately 52 per cent of our connected load. The board is designed for a load of 4,500 amp. and is built with parallel buses. The cross-section of the copper decreases toward the end of the board.

We did not have space enough to extend the board in a straight line; so it is built in the form of three sides of a square, each side being practically parallel to the walls of an almost square room. All live parts of the board are mounted from 24 to 35 in. away from the wall, which gives the operators room to work safely behind it.

A careful study was made to determine the most suitable types of materials to be used, and from this analysis and past experience we tried

Yard plan showing location of buildings and number of cable or feeder line that supplies power to each.




Starter and switch for 7½ hp.motor
3 # 14 wire - ½" conduit and 30 amp.fuse
To Starter and 100 amp. switch in Building E
7½ Hp. motor house
25 Hp. motor house
Starter and switch for 25 hp. motor
3 # 6 wire - 1¼" conduit and 65 amp. fuse
3 # 6 wire 1¼" conduit
1-Set 100 amp.cutout for 40 hp.100 amp.fuse
1-Set 30 amp. cutouts for 7½ hp. motor
1-Set 100 " "
1-Set 100 amp.cutouts for 20 hp.motor
3 # 8 wire 1" conduit & 65 amp. fuse
1-Set 30 amp.cutouts for 5 hp. motor
3 # 14 wire ½" conduit and 30 amp.fuse
600 amp. switch
Motor houses
BUILDING 6
3-350,000 C.M. cable riser to 2nd floor
3 # 4 - Wire 1¼" conduit
1-Set 30 amp. cutouts for 7½ hp. motor
3 # 14 wire ½" conduit and 30 amp. fuse
BUILDING F
3-3 10,000 C.M. Cable 3" conduit
Riser to 2nd floor
3 # 2 Cable 2" conduit to 2nd floor
BUILDING "P"
3-Sets 500,000 C.M. Cable 3" conduit to bldg. BDG 9
800 Amp entrance switches
1-Set 100 amp. cutouts for feeder to bldg. "6"
3-500,000 C.M. Cable 3" conduit
1-Set 30 amp. cutouts for 7½ hp. motor. 3 # 14 wire ½" conduit and 30 amp. fuse
200 Amp. switch for 75 hp. motor
BUILDING No. 4
BUILDING No. 1
3 # 0 Wire 1½" conduit
1-Set 200 amp. cutouts
1-Set 100 " " riser building N
Riser to 3rd floor 1¼" conduit
BUILDING N
3-400,000 C.M. Cable 3" conduit riser to 2nd floor
400 amp. switch
BUILDING N
800 Amp. entrance switch for building E
1-Set 200 amp. cutouts for feeder to building "P"
3-Sets 400 amp. cutouts for feeder bldg. BDG 9
3 # 3/0 Wire - 2" conduit

Here is a ground floor plan of several of the buildings, indicating the location of power equipment.

to select what we thought was the best. The question of price did not influence our decisions, as we wished to select materials and equipment that would give us the best results from the standpoint of continuous operation and the least expense over a period of years. Delays are a very serious consideration in this industry, because each department is practically dependent on the others. Also, owing to the fact that the greater part of the product is perishable, a few shutdowns due to burnouts might entail the loss of many thousands of dollars. Always keeping this point in mind, we tried to guard against interruptions, and I believe we have accomplished much, if we are permitted to judge from the small amount of trouble we have had since the change.

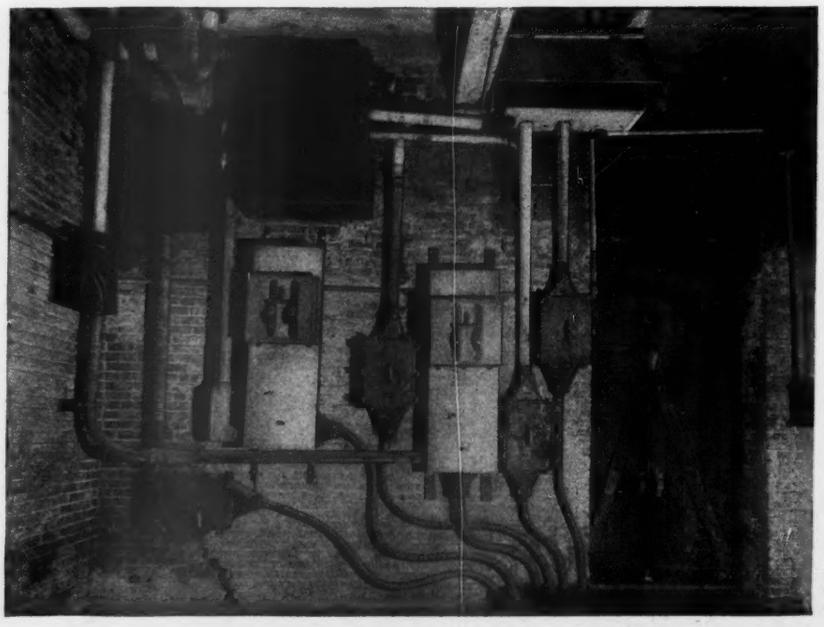
Feeders from the board are carried down to the floor where they terminate in G & W (Electric Specialty Co.) potheads. These feeders are insulated with cambric tape between the switchboard and the pothead and continue therefrom as lead-covered cable through a tunnel carrying the underground lines, which will be described later in the article.

We selected Standard Underground Cable Co. underground, three-conductor, lead-covered, cambric-insulated cable for all underground work. Cables are laid in three-, six- or nine-conductor vitrified tile. As they come up at the end of the runs, the cables are fitted with G & W Type C underground cutout boxes, to seal them, and are led into VV safety switches. Simplex Wire & Cable Co. caoutchouc double-braid, rubber-covered wire was used throughout for all distribution to motors and control equipment.

We did away with all direct-current load except about 500 amp. This is supplied by a 300-kw. Allis-Chalmers rotary converter. In case of emergency, this load can be shifted to either of two steam engines with direct-connected generators. All direct-current generating equipment is located in the old power plant and the power is distributed from part of the old switchboard. Direct current is used on some elevators, on coal-handling equipment and for charging the storage batteries for tractors. In the few other places where variable speed is necessary, slip-ring motors are used. Our stokers, for example, are driven by slip-ring motors.

In planning the distribution system the plant was divided into three groups of buildings with 20 individual circuits connected to corresponding panels on the switchboard. All circuits go out from the switchboard through a tunnel except two that are sent out on an overhead distribution line to the car shop and the fertilizer plant, which are some distance from the remainder of the plant. For these, the wires used in the old d.c. distribution system were in good condition and of the proper capacity, hence it was necessary merely to remove one wire, because with the d.c. installation we had separate lines for power and light to these groups. The present lighting circuits are fed in these two instances from a transformer mounted on a pole outside the buildings and supplied from the power line. No trouble is experienced with the lights dipping when motors are started, because the cables are large and there is unlimited generating capacity to serve them.

No distribution circuit has cables larger than 500,000 circ.mil. Where larger conductors would have been necessary, the area served was sub-



This shows how several of the underground cables are brought into one of the buildings.

The cables for this building are brought up through the underground conduit line into G & W outlet boxes to seal the ends. Type DF, VV safety switches are used here. One of the Transite board cabinets, which are used in extremely wet locations, is shown above at the left.

divided and two smaller circuits were used instead. Wire sizes on these twenty circuits vary from 300,000 circ.mil to 500,000 circ.mil by increments of 50,000 circ.mil. In the twenty circuits and their branches more than 200,000 ft. of wire and cable was used, varying in size from No. 14 wire to 500,000-circ.mil cables. All of these main circuits are carried in 2½-in. and 3-in. galvanized conduit with standard Crouse-Hinds fittings. Galvanized, instead of enameled, conduit was used because of the moisture and fumes from fatty acids encountered in this industry. The longest conduit run is about 500 ft.

The lead-covered cable runs in the tunnel are supported on horizontal cast-iron wall brackets spaced 3 ft. apart and carrying three cables on each arm. All cables in the tunnel as well as exposed parts in the manholes are rope wrapped and then covered with a coating of cement.

A number of distribution boxes were made of Transite board instead of metal on account of the moisture, ammonia and annimal fumes, and brine in the plant. Fuse blocks are mounted on slate panels. Economy refillable fuses are used. As stated, the lead-covered cable ends in G & W underground cutout boxes and then leads into the Type DF 400-, 600- or 800-amp. VV Fittings Co. safety entrance switches, which are used in the various departments on account of the moisture. In some locations where unusual amounts of acid and moisture are present Crouse-Hinds Type MK safety switches, which are housed in hot-dipped cast-iron covers, are used.

The lighting service is taken from 16 440/110-volt Moloney Electric Co. Type T lighting transformers located in the various buildings in brick vaults with concrete floors. We do not use a neutral wire but carefully balance up the loads on the different phases.

In the coolers where the warm carcasses are brought from the killing floor to cool, the ceilings and walls are dripping with moisture. In such cases we could not use conduit, because it would soon fill with water. We spent a good deal of money and time trying to get a conduit installation that would stand up, but could not keep it free from grounds. Finally we received permission from the city inspectors to use open wiring supported on Universal porcelain insulators mounted not more than 5 ft. apart and placed along the side of the ceiling beams. Wherever it is necessary to cross over on the lower side of the beam, the wiring is protected with Transite board. Transite cutout boxes are used in such damp locations.

The change-over was made a floor at a time and was all done without interruption to plant operations. The substation and underground conduit runs were put in first. New conduit runs to the motor and control equipment on a floor were then installed and at the first opportunity each old motor was removed and the new one put in its place and connected up.

In a large majority of the cases the new motor was placed on the old platform or on a new platform which replaced it. Overtime work was necessary on some of the changes, although in many cases we were able to find a motor idle for sufficient time to make the exchange. Change-overs on the killing floors were made on Sunday.

The entire job was completed in 13 mo. During this time the average number of men employed was 40, at times more, depending upon the activity. This number includes the laborers, carpenters, electricians, and so on. The carpenters were employed to rebuild motor platforms, cut and build partitions, construct the concrete forms and perform other woodworking operations. In a number of cases new motors were inclosed in separate rooms or were separated by partitions from the remainder of the department, where operating conditions are bad.

Since the change-over we have had failures of only three 7½-hp. and three 3-hp. motors. This does not include one 50-hp. motor failure caused by a laborer shoveling cinders into it to keep the belt from slipping. This record is not only due to the new equipment which has been installed but also to our method of inspection and care, which will be outlined later.

Almost all induction motors of 10-hp. or more are Allis-Chalmers Type AR. A large number of these are controlled by Allis-Chalmers Type R starters. Some Industrial Controller automatic starters are used where push-button control is necessary. Across-the-line starters are used on all motors up to 5 hp. Almost all of these small motors are of Crocker-Wheeler make. Slip-ring motors are controlled by Cutler-Hammer drum-type, non-reversing controllers with auxiliary contacts to interlock with the primary oil switch.

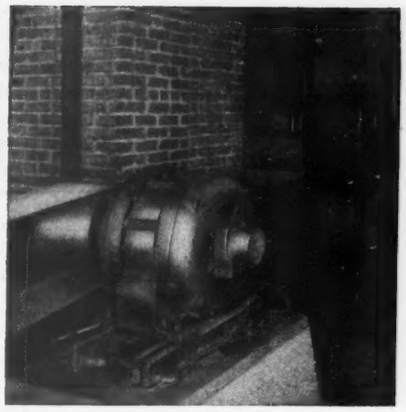
In many cases motors are built into the machine, as, for example, on some presses driven by specially designed 20-hp., Type FTR General Electric motors. These are controlled by General Electric Type CR-7076 DS-5 magnetic switches. An indicat-

Motors in Bldg. E

Floor	Card #	H.P.	Duty	Marked
2	I-5	20	Expeller (East)	E-1
2	I-6	20	Expeller (West)	E-2
3	G-14	10	Crackling Mill, E	E-3
○ 3	G-15	10	Crackling Mill, C	E-4
3	J-17	25	Glue Breaker	E-5
4	G-16	10	#5-Melter	E-6
4	G-17	10	#4-Melter	E-7
4	G-18	10	#3-Melter	E-8
2	J-18	25	Expeller (New)	E-9
6	B-30	1	Sewing Mch.	E-10
Roof	L-2	35	Frict. Elev.	E-11
2	G-24	10	Glue Rolls	E-12
2	F-22	7.5	Fan	E-13
2	O-2	55	Fan.	E-14
1	M-4	40	Glue Pulverizer	E-15
1	A-49	1/5	Fan. Blood Albumen	E-16
○ Roof	F-37	7.5	Entrail Cutter	E-17
4	G-42	10	#6-Melter	E-18
3	G-44	10	Glue Breaker	E-19
3	G-44	10	Mill	E-20
4	G-46	10	#7-Melter	E-21
4	H-29	15	#1 & 2 Melter	E-19
3	G-8	10	#3-Mill	G-8
5	E-63	5	Washer	E-21
Roof	E-12	50	Jeffry Washer	E-22
2	I-13	20	Expeller, E.end	E-23
2	I-14	20	Expeller, W.end	E-24
2	E-48	15	Blower	E-25
4	H-49	15	#8-Melter	E-26
4	H-50	15	#9-Melter	E-27
○ 4	H-51	15	#10-Melter	E-28
4	H-52	15	#11-Melter	E-29
2	J-31	25	Blower	E-30

This is the loose-leaf record of the motors in one building.

A double record is kept on every motor. This record shown here is kept according to location and shows not only the card number of the motor (second column) but also the identification or stenciled marking (last column). When a motor is moved or changed, the entry is crossed out in this building location record and a new entry made for the new motor. The number and the identification mark of the motor are never changed. A separate page is kept for each building in the plant.



One of the induction motors, and its control.

This is a 50-hp. Allis-Chalmers Type AR motor driving a hasher through a rubber belt. The motor is controlled by an Allis-Chalmers Type R starter. Connection to the power line is made through a Crouse-Hinds hot-dipped, cast-iron safety switch. The motor is mounted on a concrete base to protect it from the water that is used to wash out the room.

ing ammeter is connected into one power line to show whether the machine, which is totally inclosed, is feeding. Otherwise the press might operate for a considerable time after it was empty, or with a stoppage in the feed line. A fluctuation in the power used, as shown by the ammeter, indicates a variation in the amount of the load, which is, of course, controlled by the feed to the machine.

Some of the older equipment is operated in group drives. However, many of the new machines that are being added are individually driven through belts, gears or chains, or are direct connected, as is considered best under the circumstances. One battery of melters, for example, is driven by 15-hp. motors through Link-Belt silent chains.

We have 35 General Electric synchronous motors which vary from 35-hp. to 100-hp. rating. These are used on friction elevators, some of the centrifugal brine pumps (others are turbine driven), centrifugal water pumps, air compressors and lard hashers. All synchronous motors have direct-connected exciters and are controlled by General Electric Type CR 1034 hand-operated starters. The synchronous motors are operated at either 80 per cent leading or unity power factor.

Although these synchronous motors are largely responsible for the satisfactory power factor, every effort is made to see that all motors are operated at as near full load as possible. When ordering a motor for a drive, a great deal of care is taken to see that it will be fully loaded. For example, on one battery of individually driven machines we found that 15-hp. motors would operate satisfactorily instead of the 25-hp. motors that had been recommended. In practically all cases a machine manufacturer will recommend a motor of such size that it will take care of the greatest possible overload that can be placed on the machine under any conditions. The operating conditions in a particular plant may, however, be such that this extreme load will never be imposed. Advantage can be taken of this condition when ordering the motors.

Today we have practically no trouble in connection with the operation of the 550 motors, varying from $\frac{1}{8}$-hp. to 200-hp. rating, in addition to the 35 synchronous motors required to operate the plant. This equipment is inspected daily and maintained over 24-hr. service. All necessary routine duties, as well as new work and changes, are handled by a force of eleven men working on a six-day schedule, although seven-day operation is required.

Of this gang, one man is in the office at all times to receive telephone calls and another stays in the shop. In addition, a trouble man with headquarters in the shop is on call to answer any complaints on service interruptions, to replace fuses or lights, and so on. The daily inspections require the services of three route men. In addition, two night electricians, one for each night shift, make their headquarters in the power house, where they have telephone service.

The remainder of the gang, with a working foreman, do any necessary new work or alterations. All work involving changes or new construction estimated to cost not more than $100 is done upon the requisition of the superintendent of the department involved. Some time ago this limit was raised from $25 to $50 and recently to $100, which has simplified the work in connection with the many small tasks involved.

Whenever a motor is to be idle for any length of time, we coat the windings with a good insulating paint, and paint the frames gray with a mixture of lead and oil put up in our paint shop. In some cases where considerable acid is encountered we use No-Ox-Id, a grease paint or rust preventive compound manufactured by the Dearborn Chemical Co., which we have found to be very satisfactory. We also use this grease on all hold-down and belt-tightening bolts on our motors. In addition, we blow out the motors on a regular schedule with compressed air.

Each motor is given a daily inspection by the route men; the oil rings and oil level are examined, and the switch and starting equipment inspected. The inspector also notices whether condensate is dripping from the ceiling to the motor.

Whenever a fuse blows, the trouble man replaces it and checks it on his trouble sheet. The route man watches the installation and at the first opportunity tests the fuse rating and adjusts the overload relay, if necessary, to prevent single-phasing. We find that by keeping the overload relays set as close as possible to the required running load we can eliminate the possibility of single-phasing.

A record is kept of every motor both by location and motor number. The location record is kept by buildings and floors in a loose-leaf book with a page or more devoted to each floor as necessary. This record shows building number, floor, card number

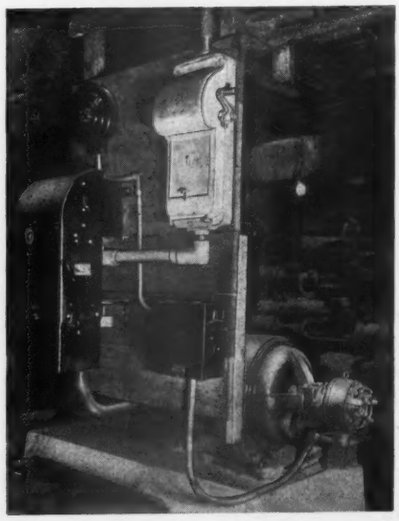
(Please turn to page 159)

D-34	No. 1,2 & 3 Ice Tank Circulator
General Elect. Co. synchronous motor	
No. 4018275-15350076-12. Type ATI-6-87½	
Amp. 49. Form PB,. H.P. 55. Power factor .8	
Three-phase, speed 1,200. Amp. field 9.5. Cycles 60.	
Volts 440. 50 °C. cont. Marked B-14	
Pulley 10" diam. 10" face., 2½ " bore	
5/8" Keyseat and setscrew.	
Brushes 1½" x 7/16" x 7/16". 5½" shunt.	
5/16" sleeve term. Bearing #192444, pulley & front end.	
(Over)	

Exciter
D.c. generator #253274, frame 2, Type KF, Form E 15350042-1. Amp. 12, speed 1,200, volts no load 125, full load 125. Kw 1½. 50° C. cont.

Sample card record of a synchronous motor.

The card number of this motor is D-34 and it is marked B-14, which indicates that it was originally installed in Building B. All motor data are contained on this card. In case a complaint comes in to the Chief Electrician's office, the foreman of the department would report trouble with the motor on Nos. 1, 2 and 3 ice tank circulator. Reference to the loose-leaf location record would identify the motor and all data would then be obtained from this card. Any trouble in operation and changes are recorded on this card.



One of the 35 synchronous motors and its control.

This 100-hp., 1,800-r.p.m. General Electric synchronous motor drives a 2,500-g.p.m. Allis-Chalmers centrifugal pump. The motor is self-excited and operates at 80 per cent leading power factor. It was necessary in this case to suspend the control apparatus from the ceiling because of space limitation. The 440-volt feeder is brought into a Type MK Crouse-Hinds safety switch with hot-dipped, cast-iron housing. The motor is controlled by a General Electric Type CR-1034 hand-operated starter with push-button stop.

Operating Characteristics of

Horizontal Quarter-Turn Belt Drives

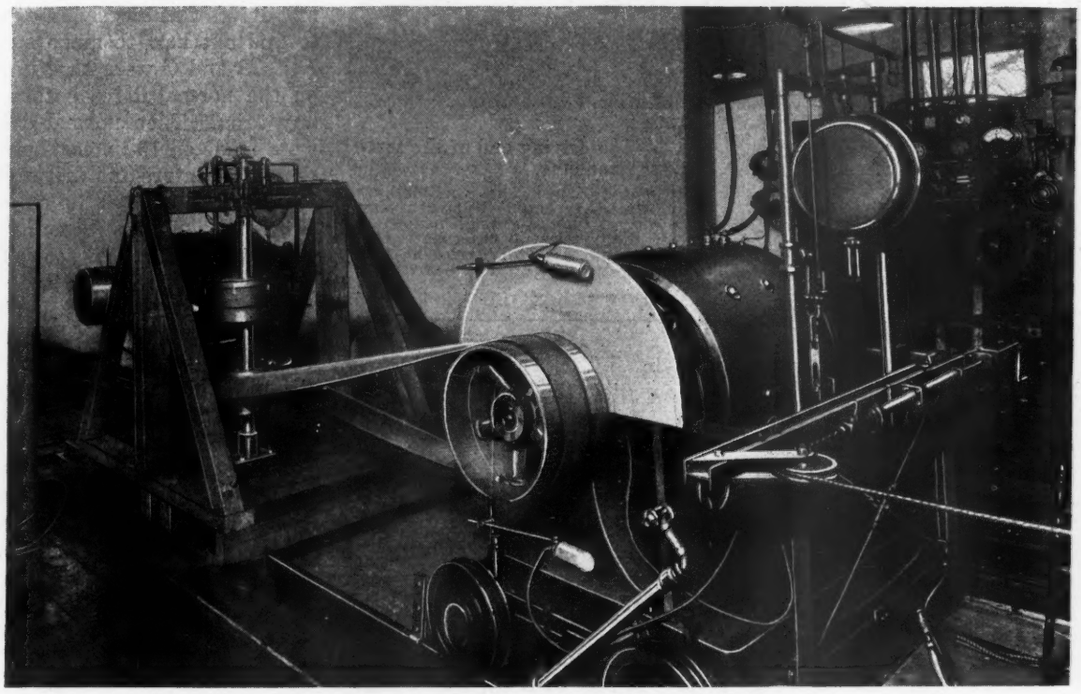


Fig. 1—The driven end of the testing dynamometer.

The belt in the foreground is under test and is driven at a quarter-turn from the vertical countershaft. This equipment measures slip, tension and horsepower transmitted.

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IN ITS research work the Leather Belting Exchange Foundation has made extensive studies concerning the effect of the operating or service conditions on the power-transmitting capacity of leather belts. Results of three previous series of tests have appeared in INDUSTRIAL ENGINEER. The first of these reports* gave the results of tests made to determine the effect of diameter and ratio of pulleys, center distance, high belt speed, and the use of the gravity idler on horizontal belt drives. The information obtained was put in the form of curves and tables in order that it might be used in laying out horizontal belt drives operating under the above-mentioned conditions.

The next report made comparative studies on the angular or inclined drive and the horizontal belt drive and gave additional data with correction factors to use in connection with data previously published. A third article contained the report on tests made on crossed-belt drives. A table of maximum center distances on such drives and other important transmission data to be considered when making such installations was included.

Additional studies, which have been made recently on the operating characteristics of horizontal quarter-turn leather belt drives, are used as the basis of this article.

The object of these experiments was to study the transmission capacity of horizontal quarter-turn drives, as compared with normal horizontal drives, and thus establish a more correct basis of design for such drives. Another object was to try out certain combinations of pulleys and center distances in the hope of learning more about the practical layout of quarter-turn drives.

Primary considerations in the design of the quarter-turn apparatus were: measurement of horsepower transmitted, measurement of slip, measurement of initial or slow running tension, flexibility in the use of pulley sizes covering a range from 6 to 30 in. in diameter and center distances ranging from 5 to 15 ft., and ease in converting the apparatus from the normal drive to the quarter-turn drive or vice versa.

A general layout of the equipment used is shown in Fig. 1. The

*These three reports were published in articles that appeared in INDUSTRIAL ENGINEER in June, 1925; April, 1926, and June, 1926. Readers not having copies of these issues on file may obtain the information on which these three articles were based by requesting copies of Reports R-13, R-14, and R-15 from the Leather Belting Exchange Foundation, 417 Forrest Building, Philadelphia, Pa.—EDITORS.

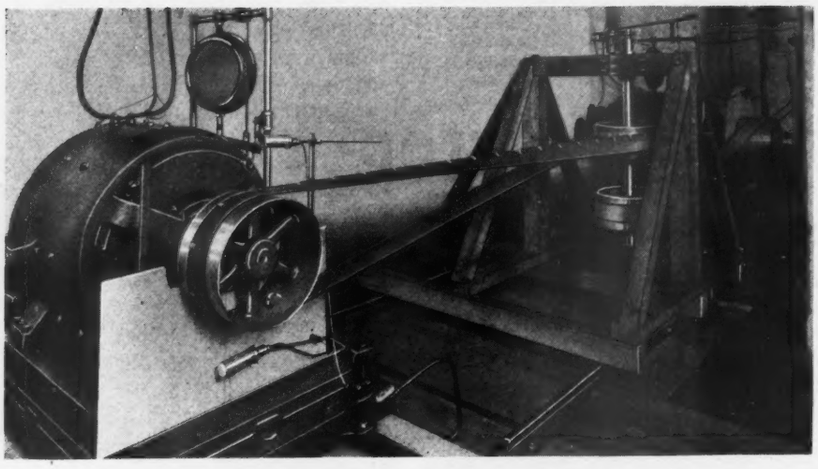


Fig. 2—The driving end of the testing dynamometer.

This motor drives the countershaft through a heavy double belt with very little slip. To make normal horizontal drives, the vertical countershaft was removed and the two dynamometers connected direct with the belt under test.

driving dynamometer of our 100-hp. belt-testing apparatus was employed to drive a vertical countershaft through a quarter-turn belt (left-hand belt in Fig. 1), and the countershaft drove the absorbing dynamometer through the test quarter-turn belt (right-hand belt in Fig. 1). The driven dynamometer (at right in Fig. 1) was mounted on a track and so could be moved back and forth to allow a variation of center distances from 5 to 15 ft. on the test drive. The tension was weighed on the tension scale as usual. The tension scale is attached to the right-hand end of the steel cable that runs off the right edge of Fig. 1. The frame for the countershaft was bolted solidly to the track at a convenient distance from the driving dynamometer.

It will be noticed from Fig. 1 that the countershaft is supported at the bottom by a step bearing and at the top by an ordinary vertical bearing. These bearings were mounted on sliding bases that allowed a sidewise movement of 14 in. in the countershaft to accommodate pulleys up to 30 in. in diameter. This was necessary because the center of the lower pulley on the countershaft had to be in a horizontal line with the center of the lower face of the pulley on the absorbing or driven dynamometer.

The countershaft constituted the driving unit of the test drive, and therefore the contactor end of the slipmeter was attached to the upper end of this shaft, as shown at the top of Fig. 1. The rotating lamp of the slipmeter was mounted as usual on the absorbing dynamometer shaft, and its rotations measured the slip of the belt between the countershaft and this machine.

The illustration, Fig. 2, which was taken from the driving dynamometer end of the test equipment, gives a good view of the quarter-turn drive that supplied the power. A heavy double belt was used to furnish steady power at the jackshaft with little slip. The driving dynamometer pulley had to be in line with the inside edge of the upper countershaft pulley. For each pulley change the countershaft was moved to bring the lower countershaft pulley into line, and therefore the driving dynamometer had to be moved to keep it in line with the upper pulley. This dynamometer was mounted on slotted rails that were long enough to allow sidewise movement.

To change the apparatus back to the proper position for the normal drive tests, the countershaft was removed from its supporting frame, and the driven machine and tension scale carriage were moved up to give the proper center distance. The driving dynamometer was then moved to the left until correct pulley alignment was attained. At short-center distances the whole countershaft frame had to be moved from the track.

The power transmitted by the test belt to the driven dynamometer was fed back to the line, thus reducing the power consumption of the apparatus about 60 per cent.

An important feature in comparative belt tests is the use of belts representative of the different conditions of surface and elasticity found in normal service. In the present case, one leather belt possessing a normal, high-friction surface was chosen as representative of leather belts at their best. Another leather belt having a buffed grain surface represented the class of belts the coefficient of friction of which has become reduced through lack of care or misuse. A third belt, known to be still lower in transmission characteristics and very constant in surface conditions, was selected to represent ability. These three belts with their dimensions are listed in Table I.

The first transmission comparison between the quarter-turn and normal drives was largely an experiment to find out how to make such tests. Belts B and C were carefully run in on the normal drive before making any tests. Then normal drive tests were made on 18-in. cast-iron pulleys on 13-ft. centers and driven to give a belt speed of 2,000 f.p.m. with the belt under a slow running tension (s.r.t.) of 288 lb. As soon afterward as the apparatus could be converted to the quarter-turn drive the belts were put on the test quarter-turn drive and tested under the same conditions. The resulting Horsepower vs. Per Cent Slip Curves, given in Fig. 3, show the normal drive to be superior in each case. However, something appeared to be wrong especially with Belt C because with this type of belt the two curves were widely apart during the creep region, which usually extends up to 1.5 per cent slip or more. Since creep is dependent upon the tension arrangement in the two strands of the belt and the elastic properties of the belt, the curves should have been closer together than they were below 1.5 per cent slip.

It is probable that this effect was due to the omission of running in before testing on the quarter-turn drive, which gave the belts no opportunity to conform to this drive. It was omitted because running in between the sets of comparative tests might have changed the belt surface and in that way destroyed the accuracy of the tests. Another possible source of error was due to the fact that as a leather belt is run in on a normal drive it improves more rapidly in the center, which results in a lower coefficient of friction at the edges than in the center. When this belt is put on a quarter-turn drive, the leather at one edge is under more tension than that in the center or on the other edge, and therefore the real intimate contact between belt and pulley, which does the pulling, takes place on one of the edges, which has a lower coefficient of friction than the center.

As a remedy for these two causes of error, we tried running in the next belt and testing it on the quarter-turn drive first. No running in was done before the normal drive test, and the belt seemed to conform to the pulleys even after being stretched out of shape by the quarter-turn drive. This was Belt A, curves of which are plotted in Fig. 4. It will be noticed that the creep lines of the two tests almost coincide and that the normal drive is a little better at high slippage. In view of these results, the latter method of test was adopted for the remaining tests.

In order to check this conclusion again and secure more accurate results with the first two belts, the tests on Belts B and C were repeated, making the quarter-turn drive tests first as with Belt A. The horsepower-slip curves for each belt, plotted from these tests in Fig. 5, are much closer together at the lower slips than in the first tests shown in Fig. 3.

Up to this time the comparison between the two drives had been made at the rather liberal center distance of 13 ft., which was chosen to bring the quarter-turn drive well within the range of good practice. It is obvious that the angle at which the belt leaves both pulleys of a quarter-turn drive becomes greater as the center distance is shortened. As a result the strain on the long edge, which takes most of the load, is increased as the center distance is decreased. Other tests at a shorter center distance bordering on the lower limit of good practice were necessary. Following the empirical rule that the center distance of a quarter-turn drive should be at least five times the diameter of the larger pulley, a center distance of approximately 7 ft. 6 in. for the 18-in. pulleys was chosen for the next tests.

Table I—Types of Belts Used in Quarter-Turn Tests

Belt	Material	Width, Inches	Thickness, Inches	Weight, Oz. Sq.Ft.
A	Single leather, buffed grain	4.00	0.205	15.3
B	Unidentified	3.92	0.195	17.2
C	Single leather, normal grain	4.04	0.221	16.3

The two leather belts A and C, after being cut to the proper length, were put on this short quarter-turn drive, run in and tested, after which the normal drive comparisons were made. The tests on Belt C followed each other directly, except for an interval of time required to change over the apparatus. As more time elapsed between the two tests on Belt A, with a greater possibility of error due to humidity or surface changes, the quarter-turn apparatus was set up again and another test was made on this drive. These are indicated as curves 3, 4 and 5 in Fig. 6; curve 5 is the extra test. This completed the power transmission comparisons of the two drives.

A number of trials on different combinations of pulleys and center distances were made in an effort to find out if there are any limiting conditions of a mechanical nature in the layout of quarter-turn drives. Practically any drive that could be duplicated on our apparatus would work, although at short center distances a terrific strain was obviously put on the long edge of the belt. In some of these short drives using a small pulley, the short edge of the belt was not in contact with this pulley at all. Instead it tended to curl away from the small pulley because of the crimping action due to the sharp lateral bend as the belt left the pulley. Obviously the life of the belt on such a drive would be very short, so short that belt life is really the determining factor in the use of such drives.

An examination of the horsepower-slip curves in Figs. 3, 4, 5 and 6 reveals that with one or two exceptions the normal drives transmitted more power than the quarter-turn drive. In all tests except those shown in Fig. 3 the power transmitted at slips less than 1.5 per cent was approximately the same for each drive. (It will be remembered that the curves in Fig. 3 are not considered so reliable as the others because the belts were not run in and therefore had not conformed to the quarter-turn drive before the tests were made.) At slippages beyond 1.5 per cent the curves separate and the small superiority of the normal drive is evident except in the case of Belt B in Fig. 5.

The horsepower figures in Table II were taken from the curves by using a piece of finely scaled cross-section paper beneath the originals. Values of the horsepower transmitted by the normal and quarter-turn drives and the difference in percentage between the two are given at 2 and 3 per cent slips for each comparison shown in Figs. 3, 4, 5 and 6. There is so little difference between most of the curves at 1.5 per cent that a tabulation of these data is considered unnecessary.

In computing the percentage difference for Belt A at 7 ft. 6 in. center distance the averages from the two curves 3 and 5 of Fig. 6 were used to compare with the values from curve 4 as indicated in Table II. The greatest difference between the two drives occurred with the high-capacity Belt C at 3 per cent slip, the difference being 16.9 per cent at 13 ft. center distance and 23.4 per cent at 7 ft. 6 in. center. It will be noticed that at 2 per cent slip the percentage differences for Belt C are much less, omitting the uncertain

Fig. 3—Tests made on two belts of high and low power-transmitting capacity.

The wide difference between the curves of the same belt up to 1½ per cent slip indicated that the belt had not been allowed time enough to conform to the quarter-turn drive.

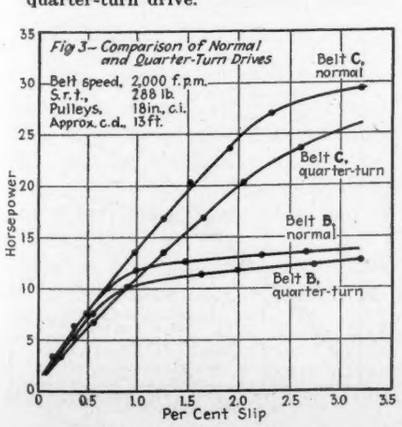


Fig. 4—Test data on the buffed leather belt after it had been broken in.

In this case the transmitting capacity of the belt up to about 1½ per cent slip was practically the same on both the quarter-turn and normal drives.

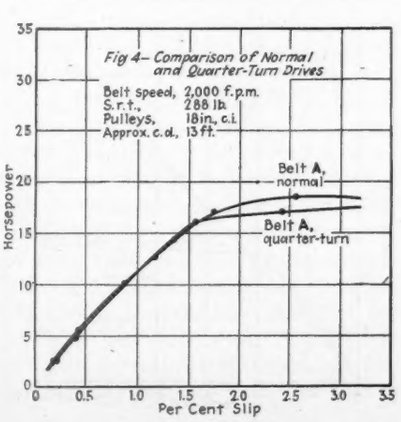


Table II—Comparison Between the Transmitting Capacities of Quarter-Turn and Normal Drives

Fig. No.	Belt	Center Dist.	2 Per Cent Slip: Horsepower, Normal	2 Per Cent Slip: Horsepower, Q.T.	2 Per Cent Slip: Diff., Per Cent	3 Per Cent Slip: Horsepower, Normal	3 Per Cent Slip: Horsepower, Q.T.	3 Per Cent Slip: Diff., Per Cent
3	B	13	13.2	11.8	10.6	13.8	12.7	8.0
3	C	13	24.9	19.9	20.0	29.3	25.3	13.0
6	A	13	17.7	16.6	6.2	18.4	17.3	6.0
5	B	13	13.3	14.0	—5.25	13.7	14.3	—4.4
5	C	13	22.9	22	3.9	32.5	27.0	16.9
6	A	7.5	17	17.2	Av.=0	19.0	19.2	Av.=3.15
6	A	7.5	17	16.8		19.0	17.6	
6	C	7.5	21.1	19.5	7.6	32.5	24.9	23.4

value from Fig. 3. With Belt A, the belt of medium capacity, the differences are small and they are greater at the longer center distances. The results from Belt B, the belt of lowest capacity, indicate very little difference betwen the two drives; in one case the normal drive horsepower is higher and in the other case it is lower than the quarter-turn horsepower, with average slightly in favor of the normal drive.

The following conclusions may be drawn from the table and curves. First, at slips up to 1.5 per cent there is practically no difference in the transmitting power of the two drives. Second, at the higher slips the advantage is with the normal drive, especially with belts of high capacity. Third, if the center distance is within the limits of good practice, it has little if any effect on the difference betwen the two drives or, in other words, center distance has no effect on this difference unless it is so short that the belt does not conform well to the quarter-turn drive.

For the purpose of design a horizontal quarter-turn belt should be from 5 to 10 per cent wider than a normal belt, other conditions remaining the same. Under most conditions an allowance of 5 per cent would be enough, but if the drive is severe, 10 per cent would be better. It is not certain that these figures would apply to a belt much wider than 4 in., but they should apply if the belt conformed well to the drive and was in good contact with the pulleys most of the way across the belt.

There is no theoretical reason why a quarter-turn belt should not be able to carry as much load as a normal belt, except that the tension varies across the width of the belt. The total area of pulley contact is certain to be less because the short edge is not in good contact at certain points, but theoretically this should make no difference; practically it may have some effect. Furthermore, the effective arc of contact is actually greater on a quarter-turn belt than on a corresponding normal belt. A glance at the driven dynamometer pulley shown in Fig. 1 will explain this.

It is true that the short edge of the belt does not come on the pulley as soon as the long edge, and in fact it may not touch all of the way around, but it is also true that the edge that is carrying the load makes contact with the pulley throughout the entire theoretical arc of contact, which is always greater than 180 deg. on both pulleys. Therefore the small differences indicated by the tests on the low-capacity belts are to be expected. The greater difference obtained at high slippage on Belt C can be partly explained by the fact that this belt undoubtedly had a better coefficient of friction in the center than on either edge, where most of the contact on the quarter-turn drive came.

In the trials of different quarter-turn drives the lengths of the long and short edges of several were measured by placing a steel tape immediately alongside each edge of the belt. The difference in length of the two edges varied from ⅛ in. to 3 in., the latter being the difference for a 30-in. pulley driving a 6-in. pulley at 6-ft. centers. This is an impractical drive, but the belt stays on, although the short edge was curling and crinkling badly as it left the small pulley. A 9-in. pulley was substituted for the 6-in. pulley, but it did not improve conditions much. At longer center distances, five times or more the diameter of the larger pulley, the long edge of a 4-in. belt would not be more than 1½ in. longer than the short edge.

The difference in length of the two edges is caused by the fact that the same edge has to take the outside of the curve formed by the belt as it leaves either pulley, and the stress is usually greater on that part of the belt passing through the curve at the driven pulley. The shorter the center distance for any given pulley the sharper this curve and the greater the strain on the belt. Since the curvature depends upon the pulley diameter and center distance, their ratio determines the maximum bend the belt will have to make (which will be on leaving the smaller pulley). It follows, then, that this ratio has an important influence on the life of the belt. The fact that belt life is an important factor in the choice of the minimum ratio betwen the center distance and the large pulley diameter brings in an economic problem that can be more easily solved by a study of quarter-turn belts in service than by a laboratory study.

A few remarks on points of general interest in the operation of

Fig. 5—Comparative transmitting ability of two different types of belting.

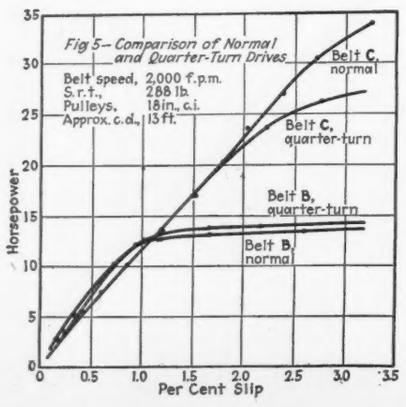
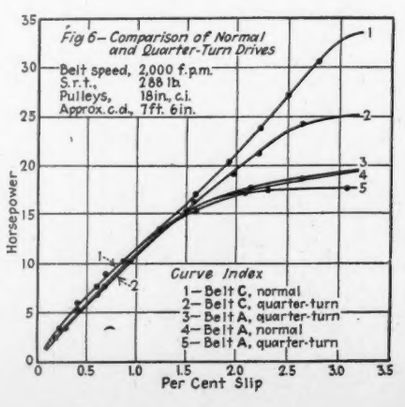


Fig. 6—Results of tests on leather Belts A and C operating with short center distances.



quarter-turn drives might be of some value in this discussion. In almost every instance where a leather belt was installed fairly tight, a certain amount of squeaking was present even at no load. This was caused by the tendency of the belt to slip sideways just before it left the pulleys. If the belt was under load, the squeak usually originated at the side where the belt left the driven pulley, because this was the tight side and naturally offered more resistance to sideways sliding than the loose side. In the case of the 30-in. pulley driving the 6- and 9-in. pulleys at 6-ft. centers, the side slipping was great enough to cause bad heating of the smaller pulley.

In general, a quarter-turn belt will stay on the horizontal pulley better when it is used as the driver, because if it is driving, the loose or sagging strand of the belt comes on to the driven pulley, which is in a vertical plane, and therefore the belt will run true regardless of the sag of the loose side. If the driver pulley is in a vertical position, the loose side of the belt feeds on the horizontal pulley and the sag of this strand tends to make the belt run off the lower side of the pulley. When the load is variable, the belt has a tendency to run in a different place on the horizontal pulley for every change in load. Tightening the belt helps to overcome this trouble, which would be experienced more with loose belts that are operated at long centers or at high speeds.

Briefly, some of the more important results and conclusions drawn from these tests on quarter-turn belts are as follows:

1. For the purpose of design a horizontal quarter-turn belt should be from 5 to 10 per cent wider than a normal belt operating under the same conditions. There is very little difference in the transmitting capacity of the two drives at slips below 1.5 per cent and more or less difference at higher slips, depending on the belt.

2. The difference between the capacity of normal and quarter-turn belts at normal slips is probably small at any reasonable center distance above the minimum that is used (five times the large pulley diameter).

3. Any quarter-turn drive that can be duplicated on our testing apparatus will run—that is, the belt will stay on at least for a time and transmit power. Therefore the limiting mechanical conditions, such as the ratio of the larger pulley diameter to the center distance, should be determined by other considerations.

Changing Distribution System

(Continued from page 154)

of motor, horsepower, duty (machine it drives) and stencil identification or motor marking. One of the pages from this record book is shown in an accompanying illustration. For example, the key letters or figures in the stenciled marking identify the building; this is followed by a number identifying the particular motor. Thus, in Building K the motors are stenciled K-1, K-2, and so on. Some buildings go by numbers, and here the motors are identified, as in Building 16, by the number 16-1, 16-2, and so on. The motor always retains this number, even though it is moved to another building.

Motor data are recorded on a 3x5-in. card. This is filed by card number and carries the nameplate data, pulley size, key dimensions, bore, marking on motor (stencil number) and manufacturer's number of bearing or bearing size. One of these cards is also reproduced here. Any necessary repairs, trouble or changes in location are recorded on the back of the card. When a motor is moved, the number of the new motor replacing it is substituted in the loose-leaf building record. A corresponding change is made in the loose-leaf record when this motor is again put into service either in that building or some other.

Although the amount of repair work necessary on our a.c. equipment would be very much less than in the case of the d.c. equipment which we formerly had, our requirements and operating conditions are so severe that we can maintain the high operating standards which we have set only by constant vigilance.

After installation, a test is made with an Esterline graphic meter on all new motors and the chart is filed away for reference. Should we desire at any time to put an additional load on any particular motor, it is not necessary to make another test to find out how much we can add. This test record is always available. However, if an additional load is put on any motor, a new test is taken and the old record destroyed or placed in a dead file for reference.

An example of the good service we are getting from our equipment is in connection with a 10-hp. Allis-Chalmers motor drive on a hot beef chain. This carries the freshly killed beeves past the butchers, who perform various operations on the carcasses before they pass into the cooler. The motor driving the chain starts under load and is operated by an Industrial Controller compensator from a push button. Conservatively, this motor is started and stopped more than 100 times a day. During the past 2 yr. it has been necessary to renew only two contacts. This service is due to the careful daily inspections of the equipment.

Although a large amount of work was involved in making the change-over from direct to alternating-current power, we are sure that it has paid not only from the standpoint of reduced maintenance but, what is more important, in the elimination of breakdowns and interruptions to service.

One Way to Obtain Constant Spray Density

MAINTAINING a spray of constant density is a difficult problem. The greatest trouble is from clogging of the nozzle. Another source of trouble is due to changes in the density of the liquid, particularly with a lowering of temperature. Also, these troubles increase with the fineness of the spray required.

In one plant a spray as fine as the finest mist was required. The operating department had about given up the problem because it could not be sure of maintaining a spray of constant fineness; variation in density would have been fatal to the product.

The Master Mechanic finally evolved a plan that eliminated the nozzle and gave the fineness of mist wanted. This plan consisted of directing a high-pressure stream against a metal plate. In place of the nozzle the liquid was discharged from the open end of a small pipe. Of course, the liquid spattered and most of it ran down and off the plate, but this was collected and pumped back against the plate. However, above this spattering a constant mist arose that was finer than anything that had been produced before. The necessary arrangements were made to have the material to be treated exposed in this mist, and the most important troubles of the operation were over.

Uses of Electric Drills *in Maintenance and Repair Work*

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Fig. 1—Drilling holes in the ceiling is easy by this method.

The stand shown in Fig. 2 is mounted on the platform of an elevating-platform, electric industrial truck and then raised to the ceiling. The feed while drilling is obtained by the lever on the drilling stand.

EVERY man responsible for maintenance knows the value of any equipment which will enable him to drill holes quickly and easily in the most unusual and inconvenient places and through the greatest variety of materials. The electric drill is a most useful tool in the equipment of the modern maintenance man, whether his work be in a steel mill, a textile mill, a mine, or skyscraper.

Let us consider holes in metal, or more specifically, in mild steel or cast iron. To drill a ½-in. hole in such material is a very tiresome job when done by hand and it is often impossible or too costly to take the work to a drill press. A carbon-steel, twist drill can be operated in such material, at a cutting speed of 40 ft. per min., which is about 300 r.p.m. for a ½-in. drill. In passing it is convenient to remember the following rough-and-ready rule for determining the practical speed for any size of carbon steel drill used in mild steel: R.p.m. = 150 ÷ diameter of drill. Three hundred revolutions per minute is a much higher speed than can be obtained for any appreciable time with a hand-driven, ½-in. drilling device. An estimate of the comparative speeds obtained will give a fair comparison of the length of time required to do a given job.

If we apply the above rule to find the speed for a ⅜-in. twist drill in mild steel we get 150 ÷ 0.375 = 400 r.p.m. It is therefore apparent that our drilling machine should be capable of operating at various speeds to obtain the best performance over the wide range of work found by the maintenance mechanic.

Most electric drills are equipped with a motor which accomplishes automatically this adjustment of speed to drill size. It may be assumed that the working range is from two-thirds to one-half of the no-load speed. The nameplate of the machine may show the no-load speed, the speed at rated load, or both. The speed at rated amperes will be about one-half of the no-load speed. When the speed at rated load is considerably less than half the no-load speed there is ground for suspicion that the motor is overrated. A rating of 550 r.p.m. at no load and 300 r.p.m. at a load of 4.5 amp., 110 volts is about right for a ½-in. capacity machine.

Electric drills are rated according to their capacity in mild steel and are equipped with a chuck for straight-shank drills or a socket for taper shank drills in accordance with these ratings. The usual practice is to equip them with chucks, for straight-shank, twist drills in ¼-in., ½-in. and ⅝-in. sizes and with Morse taper sockets for larger sizes. The No. 2 Morse taper socket takes standard, taper-shank drills up to the $\frac{33}{32}$-in. size and the No. 3 socket accommodates drills up to the 1¼-in. size.

The ½-in. size drill is the maintenance man's tool. Whether or not

a larger or a smaller size is also desirable will be apparent when we have shown the performance to be expected from this popular size. Obviously the tool will not always be used for drilling ½-in. holes in steel. When the work required is less than the rated capacity of the drill, the operating speed will automatically increase and approach the no-load speed. Since the ½-in. tool weighs from 16 to 25 lb. it is unusual to use this size for any appreciable amount of work within the capacity of the ¼-in. tool. The latter weighs 5 or 6 lb. and has a speed and form that is more suitable for small work.

Contrary to first impressions, to turn a twist drill in wood requires more power than does the same drill in steel or other metals. This is because such a bit does not clear itself readily. The remedy is to withdraw it every inch or so of depth so as to clear the hole. It is a very good ½-in. tool which cannot be stalled in hard wood by a husky man. This is a simple test of power in an electric drill.

When holes are to be drilled in wood, it pays to have proper bits. The ordinary wood bit with the lead screw is not suitable unless the threads are ground off leaving a point for centering only. The machine-type wood bit is suitable and can be obtained in sizes up to 1¼ in. with the ½-in. shank. A good ½-in. tool will handle this bit in any dry, seasoned wood. With proper bits, holes up to 2 in. in diameter can be drilled in soft woods. For this purpose we may classify woods as follows:

"Soft" woods: poplar, spruce, white pine, cedar, white wood, mahogany.

Working Capacity of ½-in. Electric Drill

Material	Type of Drill to Use	Maximum Diam. Hole, In.
Hard Steel and Iron	High Speed Twist Drill	¼
Mild Steel, Cast Iron, Brass, etc.	Carbon Steel Twist Drill	¼
Any Seasoned Wood	Twist Drill	½
Seasoned Soft Wood	Wood Bit without Lead Screw	2
Seasoned Hard Wood	Machine Type Wood Bit	1¼

"Hard" woods: ash, maple, oak, southern pipe, birch, chestnut, hemlock, hickory, walnut.

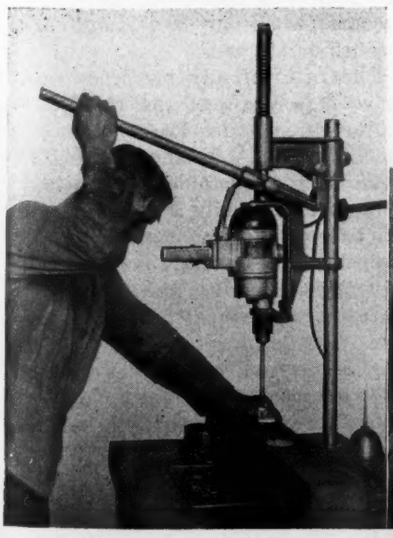
Getting the necessary feed pressure when drilling metal is sometimes tiresome unless a feed screw or equivalent device is applicable. Very few operators have appreciated, until lately, the full value of the light stands available for use with the electric drill. Fig. 2 shows a ½-in. tool in such a stand, which is obtainable for an additional investment of less than half the cost of the drill itself. This device is so light that it may be moved about and used as a means of obtaining feed pressure. Fig. 1 shows how some mechanics use it on a Revolvator or electric tiering truck for drilling ceiling holes for motor mountings, automatic sprinkler systems, overhead track installations, and the like.

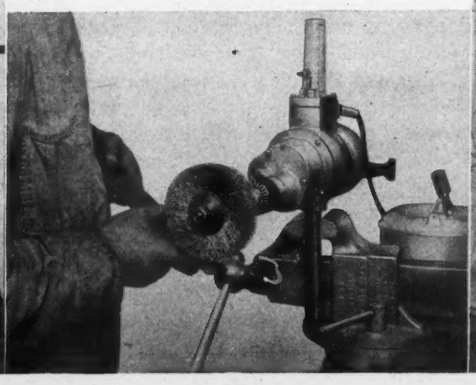
Although an electric drill does not make a thoroughly practical grinder or scratch brush it may be used for numerous odd jobs of this nature, as suggested by Fig. 3, in which case the drill is held firmly in a vise.

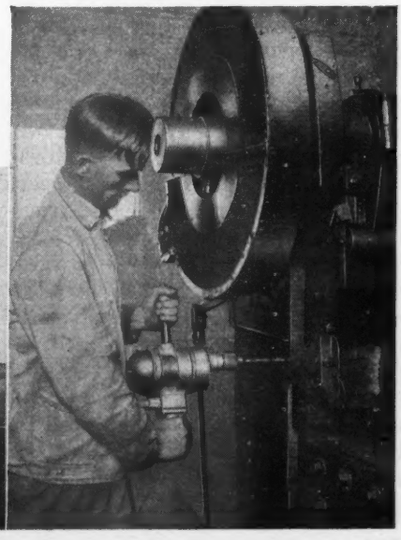
The table at the top of this page shows the maximum diameter of hole that a good, ½-in. electric drill will cut in different materials when used with the proper type of drill, which is also indicated in each case.

Figs. 2, 3 and 4—Here are some ways of increasing the usefulness of your electric drill.

Fig. 2 shows a portable stand that will greatly increase the convenience and speed of drilling. For light work, a grindstone or buffer may be mounted on the drill, as shown in Fig. 3. When working around machines, such as shown in Fig. 4, an electric drill will save much time and labor.





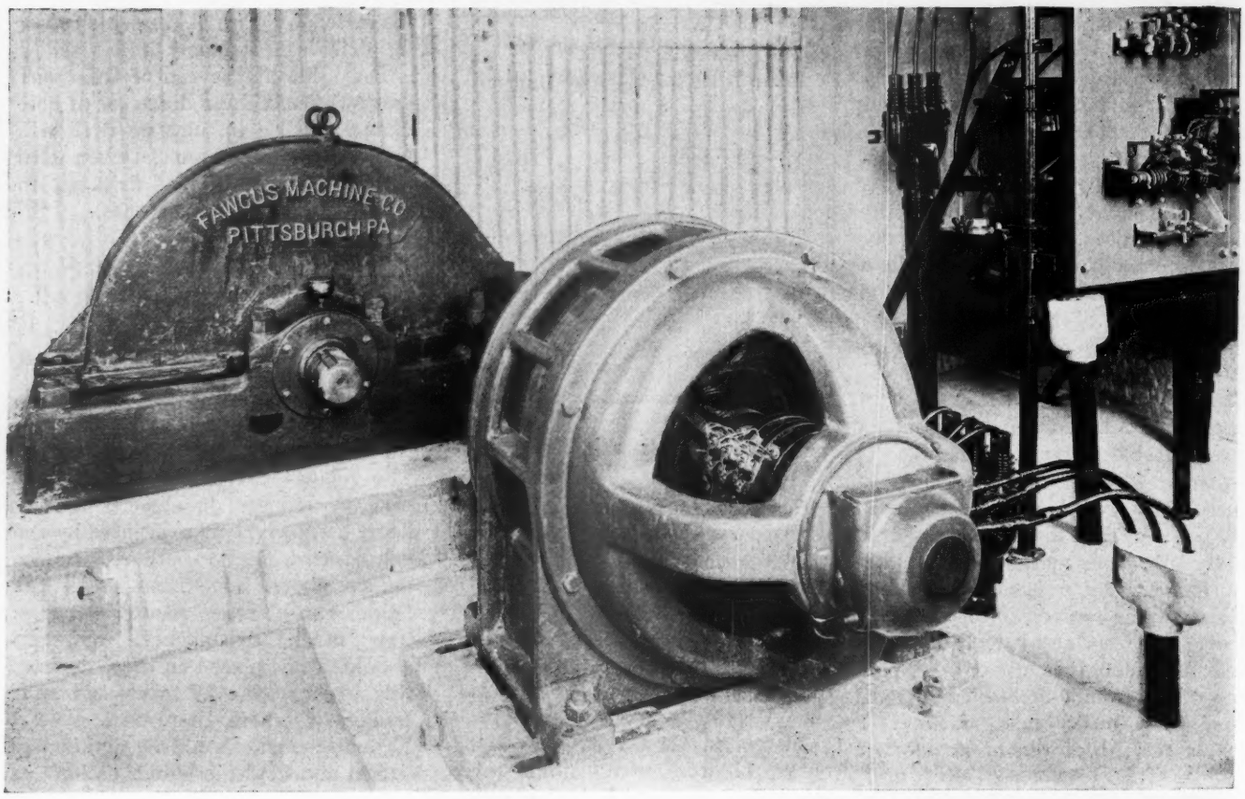


Precautions in the Use of Portable Ladders

SAFE ladders, whether permanent or portable, are a necessity, as is pointed out in a report by the National Electric Light Association. The report further states that slipping of ladders on smooth or oily floors can be largely prevented by the use of cork feet or other adequate ladder shoes. In some cases the ladder can be made secure by ropes. Too much dependence, however, should not be placed on these devices, and when necessary to use a longer ladder or where there is a special hazard, a man should be detailed to guard and hold the ladder as long as another man is on it. Sufficient help should be provided to handle long, heavy ladders.

Stepladders should be of substantial construction and kept in first-class condition. Permanent ladders should be solidly anchored. Extra-long, permanent ladders should have a protecting cage built around them.

The practice of carrying tools and material up and down ladders has caused a number of serious accidents. A light handline attached to each permanent ladder should be used to hoist material that cannot be carried in the pockets without danger of falling out. Both hands must be free for climbing at all times.



In this instance a mine fan 21 ft. in diameter is driven at 68 r.p.m. through a herringbone, roller-bearing, reduction unit.

Application of

Gears and Speed Reducers on Motor Drives

By GORDON FOX

Electrical Engineer,
Freyn Engineering Company,
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PROBLEMS incidental to the proper connection of a motor to its load should receive as careful attention as the selection of the motor. Previous articles in INDUSTRIAL ENGINEER have covered the use of flexible couplings and belts for connecting the motor to its driven machine or load. This article will take up the considerations involved in connection with the use of gears and speed reducer or speed transformer units on motor drives.

In this discussion the term "gear drives" refers to geared connections, such as the back-geared motor or the pinion drive on the motor shaft driving a gear on the load or other gear connection between the motor and its driven machine or load, but does not include speed reducers, which are discussed under later headings.

Gear drives permit compact arrangement, are positive and afford a definite speed reduction. They are particularly adapted for low-speed work for which other drives may be unsuited. Gear drives have fair efficiencies, which range from 90 to 98 per cent for each gear reduction, depending upon type, speed, lubrication and other operating conditions. For long life and efficient operation, gear drives require good initial alignment, which must be well maintained. They also require lubrication and generally inclosure for safety, for protection against dust and to facilitate lubrication.

On the other hand, gears transmit to the motor most of the shocks to which they are subjected. Gears also transmit vibration and are usually more or less noisy, especially with high speed and metal-to-metal contact. These objectionable features are increased when the gear teeth become worn or are improperly meshed or aligned.

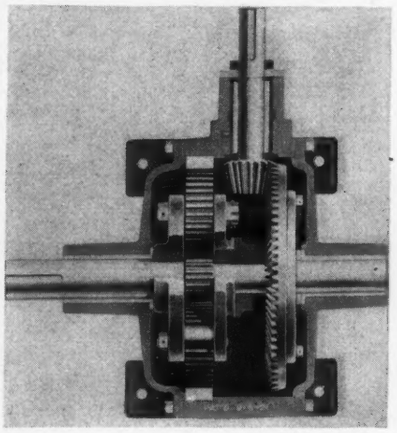
The ratio of any particular gear drive depends upon the relation of motor speed under load and desired machine speed. In the case of constant- or adjustable-speed motors this ratio is easily determined. In the case of varying-speed motors the proper ratio is not always so readily determined, because the motor speed varies with the load. For drives that are started and stopped frequently, the factors of machine and motor inertia may materially affect the selection of the proper gear ratio.

The allowable ratio for a single reduction of spur gears is limited by the allowable diameter and surface

speed of the gear and by the minimum number of pinion teeth. For small motors a 10 : 1 ratio is allowable; for motors of moderate size, 8 : 1 is about the maximum ratio permissible. The motor pinion should have at least fifteen teeth, if possible, because the teeth of smaller pinions are weakened by the necessary undercutting. In determining a ratio of gearing it is well to avoid the maximum possible ratio, as this leaves no margin for future change, should such be found advisable. It is better to use an intermediate ratio, but to provide clearances that will permit a change of the gear ratio in either direction, if desired later. In calculating a gear reduction the gear should, if possible, have a prime number of teeth in order that the shocks due to a repeated cycle of operation may be distributed; the use of an odd tooth prevents the same teeth from meshing so often.

When motors have double-extended shafts, placing the pinion on the commutator end should be avoided, if possible, because the shocks and vibration are more serious and the bearing wear is likely to be more rapid. Outboard bearings should be used for all geared motors of 100 hp. and larger and, in many cases, for smaller motors. Also, outboard bearings should be used for general-purpose motors of 50 hp. and above when subjected to reversing duty or severe fluctuating loads.

The motor pinion should be located preferably on the same horizontal level and to one side of the driven gear. Bearing wear on slight errors in elevation then have little effect. It is not good practice to locate the motor pinion directly below the driven gear. Bearing wear is then likely to throw excess weight on the motor bearings. It is also difficult to remove armatures so located. If the arrangement is such that motor elevation affects the meshing of the gearing (the same is true in connection with flexible couplings on drives), it is advisable to have the motor support a trifle low and to build up with shims under the motor feet. This arrangement also permits adjustment to care for slight differences between individual motors.



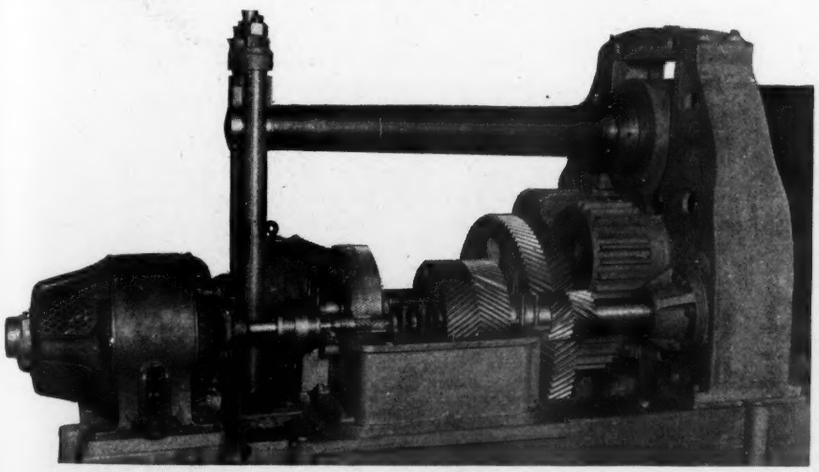
Cutaway view of a right-angle planetary reducer.

The high-speed drive is connected to the small bevel gear and the low-speed shaft is at the left. This is a Ganschow single-reduction planetary unit. In the latest model a roller bearing is used on the high-speed shaft.

Gears are usually of cast iron or cast steel with cut teeth, whereas pinions may be of steel, brass, fiber, rawhide or cloth. The two latter types have end plates of brass. Steel pinions have excellent life and are not affected by temperature or moisture, but are noisy and cut quickly unless well lubricated. Cast-steel gears are about 75 to 100 per cent stronger than those of cast iron.

Here the input speed of 900 r.p.m. is reduced to 3¾ r.p.m.

This Farrel herringbone reduction unit is used to drive a plate-bending machine.



They should be used for important work, where shock or overload may be expected or where the face of a cast-iron gear would exceed 4½ in. The cost of cast-steel gears is about 60 to 100 per cent more than for cast-iron gears of the same dimensions. This difference is greater on large gears than on small ones.

The pinion is subject to the more rapid wear, due to its smaller diameter; therefore it is important to have a pinion of good wearing qualities as well as of sufficient strength. Heavy-duty steel pinions are usually forged of 0.30 to 0.40 per cent carbon steel and are frequently heat-treated to increase their strength and durability. This is particularly true in connection with crane and other mill motors.

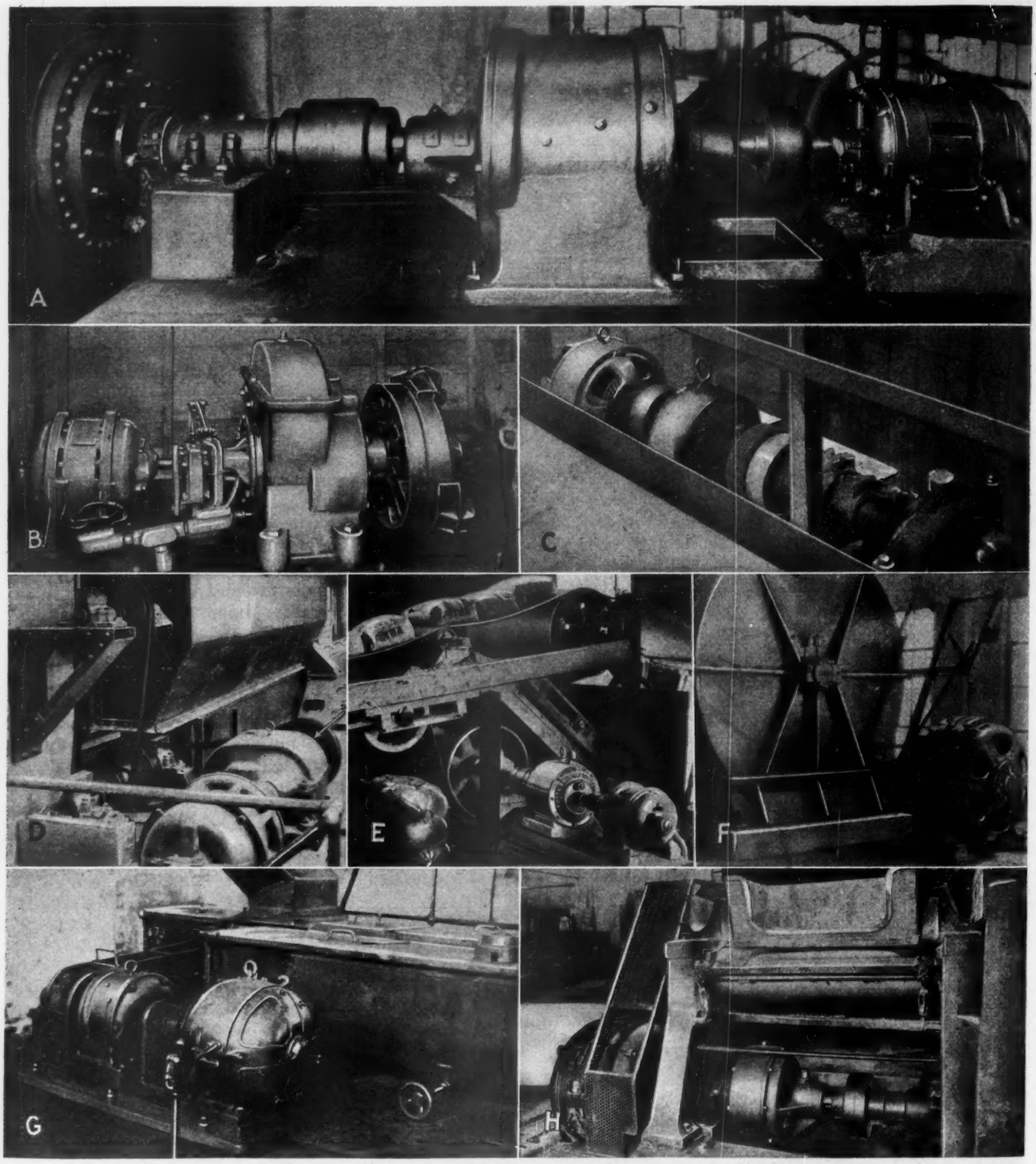
Iron and steel gears ordinarily become noisy at about 800 f.p.m. linear speed, but may not be disagreeably noisy below 1,200 f.p.m. or even higher. Where it is desired to employ high surface speeds without noise, brass, fiber, rawhide or cloth pinions may be used. Brass pinions, although somewhat quieter, have shorter life than those of steel; they are particularly adapted to extreme conditions of heat and moisture, which prohibit the use of a non-metallic pinion where noise is objectionable.

Fiber pinions are quiet and can be used under any ordinary conditions and many unusual conditions, except extremes of heat and moisture. Rawhide pinions are satisfactory unless subjected to extremes of heat or moisture, excessive load fluctuations, or frequent starting, stopping or reversing. The American Association of Gear Manufacturers recently adopted the recommendation that all non-metallic gears or pinions be estimated on a basis of 75 per cent of the rating of cast-iron gears of corresponding dimensions.

The surface speed of a rawhide pinion is limited more by rapid wear than by noise. A speed of about 2,000 f.p.m. is a fair average limit, but 2,500 to 3,000 f.p.m. may be used under favorable circumstances of attendance and lubrication, in the absence of moisture and for intermittent service where the life of the pinion is not important. Cloth pinions are quiet, not easily affected by ordinary heat or moisture, are quite elastic and give good service when subjected to strains and shocks. The allowable surface speeds correspond to the values for rawhide.

Where quiet operation is desired,

Eight Applications of Speed Reducers
on Motor Drives



A—Here a 15-hp. 1,160-r.p.m. motor drives paper mill equipment at a reduction of 192 to 1 through a D. O. James planetary reducer.

B—A car haul is driven by this Hill-Clutch Type C 46:1 speed transformer through a friction clutch and solenoid brake control.

C—Because reducers are totally enclosed they can be operated satisfactorily in very dusty surroundings, such as shown here. This is a Ganschow planetary reducer.

D—This screen and screw conveyor in the packing plant of the Peerless Portland Cement Co., Detroit, Mich., is driven at the required speed by a Palmer-Bee mill-type speed reducer.

E—Here a conveyor for loading cars in the Aetna Portland Cement Plant, Bay City, Mich., is driven by a Foote IXL non-planetary speed reducer.

F—One of 11 elevator drives requiring 175 hp. in a single reduction from 485 to 27½ r.p.m. through Fawcus herringbone gears. The motor is connected to the pinion by a Webster special steel-plate clutch. Power is transmitted from the gear shaft to the elevator headshaft through a Fawcus semi-flexible coupling.

G—An example of a compact drive arrangement of a D. O. James planetary speed reducer driving a screw conveyor through a chain.

H—This is a Philadelphia 10½:1-ratio spur gear speed reduction unit which is connected to a 50-hp., 1,200-r.p.m. motor that drives a two-roll calender mixing machine in a linoleum plant.

Table I—Safe Working Stresses for Gear Materials

These values are to be used in connection with the computation of a gear or pinion and must be reduced according to the strength factors in Table II.

	Ordinary Grade	High Grade
Non-metallic	6,000	8,000
Cast-iron	6,000	8,000
Phosphor bronze	9,000	12,000
Cast steel	12,000	15,000
Steel	15,000	20,000-35,000

Table II—Strength Factors for Gears

Pitch Line Speed, Ft. Per Min.	Strength Factor
100	0.857
200	0.750
300	0.666
450	0.571
600	0.500
900	0.400
1,200	0.333
1,800	0.250
2,400	0.200

rigid and massive supports and close-fitting bearings, both on motor and driven machine, are conducive to a noiseless drive. Where the mounting or foundation of the motor and its machine are not substantial enough, the tooth pressure tends to force the gears and machines apart, which adds to tooth wear and noisy operation. The pinion should always be placed as close as possible to the motor bearing. Long overhung pinions not only increase the pressure on the bearing but also increase the likelihood of a sprung or bent shaft in case of a serious shock load.

Gears must be kept well oiled, and at high speeds some method must be used, the effectiveness of which will not be destroyed by centrifugal force, to maintain an oil film at the point of tooth contact. Rawhide gears should not be oiled, but should be lubricated with talcum and graphite or graphite and lard oil. Gears should always be guarded, not only for safety and for protection but also to prevent throwing of the lubricant. Inspection openings should be provided in the gear guards at the point of meshing.

The selection of gears is a rather comprehensive subject and can be treated only briefly in this limited space. However, a method of determining sizes of spur gearing, which is based on the Lewis formula, will be outlined. Usually the horsepower, speeds and approximate distance between centers are given. With the gear ratio and center-line distance known approximately, a pinion diameter can be selected for trial. It is first necessary to calculate the tangential pressure at the pitch line from the formula:

$$T = (Hp. \times 126{,}000) \div (D \times \text{r.p.m.})$$

where T = Tangential pressure at pitch line in pounds

$Hp.$ = Horsepower to be transmitted, including allowance for starting and overloads

D = Pinion diameter in inches

$r.p.m.$ = Pinion speed.

The approximate pinion diameter being known, the linear speed at the pitch line can be readily calculated. From Table I select a unit stress for the material to be used for the gear or pinion, using whichever is weaker if both are not of the same material. Correct this unit stress by multiplying by the strength factor given in Table II for the linear speed determined. The resultant unit stress may now be used for determining the gearing.

Let T = tangential pressure at pitch line in pounds

S = unit stress allowable

P = pitch diameter in inches

Y = correction factor for tooth outline from Table III

V = linear velocity at pitch line in feet per minute.

Assume a value for P and solve the following formula to determine a value of F.

$$F = TP \div SY$$

Also solve the following formula to determine a value of F:

$$F = [(0.15 \sqrt{V}) + 9] \div P$$

If the two values of F thus obtained are approximately the same, the assumed value of P is satisfactory. Otherwise a new value of P must be assumed and the process repeated.

When satisfactory values of P and F are determined as above, the number of teeth in the resulting pinion and gear and their general proportions can be checked and the nearest commercial size selected.

Drive Considerations When Using Speed Reducers

Self-contained spur- and worm-gear speed reduction units are gaining popularity, particularly where the reduction ratio is high. These units afford a number of advantages in comparison with a train of gears. Ordinarily, the reduction unit occupies less space than a gear train for a given reduction of speed, and also permits of large ratios in a unit assembly. Their use often makes it possible to use a higher-speed motor.

Table III—Outline Factor "Y" for Gear Calculations

No. of Teeth	Outline Factor 14½ Deg. Involute and Cycloidal	20 Deg. Involute
12	0.210	0.245
13	0.220	0.261
14	0.226	0.276
15	0.236	0.289
16	0.242	0.295
17	0.251	0.302
18	0.261	0.308
19	0.273	0.314
20	0.283	0.320
23	0.295	0.333
25	0.305	0.339
27	0.314	0.349
30	0.320	0.358
38	0.336	0.383
50	0.352	0.408
75	0.364	0.434
100	0.371	0.446
300	0.383	0.471
Rack	0.390	0.484

Because the reduction units are inclosed, they are easily lubricated and are protected so that they can be used in dirty and damp places. Also, because of their inclosure, they are safe. In most designs of spur-gear reducers a straight-line drive is afforded, which is advantageous. The units transmit torque directly through couplings and do not impose flexural loads on the bearings of the motor or the driven machine.

Briefly, speed reducers, or speed transformers, as they are frequently called, consist of a cast-iron or cast-steel case, fitted with especially arranged spur-gear trains or with a worm and worm gear. The discussion of these will be treated separately here.

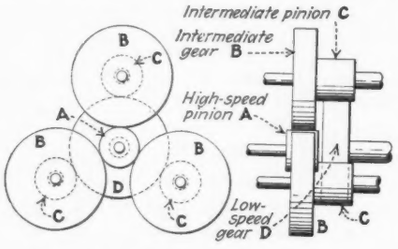
The several types of spur-gear speed reducers may be classified as: (1) plain spur: (2) planetary; (3) non-planetary; and (4) parallel shaft, such as mill type, helical and herringbone. The construction and operation of the plain spur, planetary and non-planetary reducers are illustrated by sketches and their operation is described in the caption accompanying each and so will not be repeated here. In each case high reductions are obtained by means of two-, three- or multiple-stage reductions, which consist of two or more single-stage units built together in the same case.

The first three of these spur-gear types of reducers have several features in common—namely, (a)

straight line reduction; (b) two reductions in a single stage; (c) the use of three intermediary gears driven by the high-speed pinion; and (d) these gears divide and distribute the torque on both the high-speed pinion and the low-speed gear.

Each of these types also has some advantages due to the design. However, a point often overlooked is the effect of the quality and accuracy of manufacture, which affects the efficiency of transmission, life of the unit and satisfactory operation. In some units ball or roller bearings are used on some of the bearings.

Although spur-gear reduction units are a straight-line drive, modifications are obtainable to give a right-angle drive. This consists of a bevel gear on the incoming shaft, which enters on the side, that meshes with its mating bevel on what would ordinarily be the incoming shaft. A cross-section of a right-angle, single-

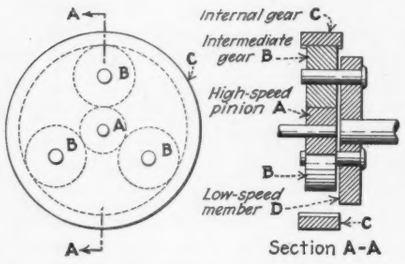


The plain spur-gear reducer consists of a series of spur gears, each revolving about its own center.

The high-speed pinion meshes with three idler gears, contacting on the pinion at points 120-deg. apart. On common shafts with these three gears are three pinions meshing at points 120 deg. apart with a larger gear which is keyed to the low-speed shaft. High-speed pinion *A* meshes with the three gears *B*; pinions *C* mesh with gear *D*. Essentially, there are five elements in this single-stage reducer: namely, the high-speed shaft and pinion, three counter-shafts each carrying a large gear and smaller pinion, and the slow-speed gear with its shaft. Although there are two reductions, this is known as a single reducer. The double reducer has two stages in series, with a partition between them.

reduction planetary unit is shown in one of the accompanying illustrations. The bevel gear, however, gives some additional reduction.

Right-angle, spur-gear drives may be arranged for right- or left-hand connection or for vertical drive with the low-speed shaft extending either up or down. The vertical units are widely used on agitator drives; this permits placing the motor at one side out of the fumes, heat or moisture. Also, right-angle drives are used where space will not permit a straight-line connection, such as on a machine located alongside an aisle or wall.



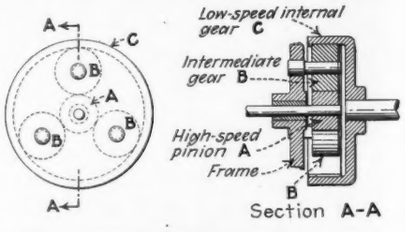
Cross-section view of a planetary gear reducer.

The planetary reducer employs a stationary internal gear in addition to spur gears. The high-speed pinion *A* meshes with the three intermediate gears *B* which are journaled on shafts that extend from plate *D* which is integral with or keyed to the low-speed shaft. The three intermediate gears *B* also mesh with a stationary internal gear *C*. This arrangement causes the entire unit consisting of the three intermediate gears *B*, the plate *D*, and the low-speed shaft to rotate. This description refers to a single reducer. For high ratios two or more such stages are combined in series.

The parallel-shaft type of gear reducer is essentially a condensed gear train that is inclosed and assembled as a unit. Sets of this type are shown in accompanying illustrations. This type of reducer may or may not be a straight-line drive, depending upon the specific design. Some manufacturers specialize on spur gears and others on herringbone gears for these units. Such units have the reduction field practically to themselves in the transmission of large amounts of power.

The amount of reduction obtainable with the various units varies somewhat with the different types and designs of the different manufacturers. Roughly, the variation is from about 3 : 1 or 4 : 1 in the single-stage units up to about 200 : 1 in the multiple-stage units of the plain spur, planetary and non-planetary types. Parallel shaft reducers begin at decimal ratios slightly higher than 1 : 1 to several hundred to one in the multiple units. Sometimes it is feasible to equip a reducer for a given gear ratio adapted to present requirements with provision to change to a new ratio at a later date by changing the gears.

All gear-reduction sets have a given torque capacity, the horsepower rating depending upon the speed and the ratio of reduction. The higher the ratio of reduction the lower the horsepower rating. These sets are available for motors up to about 200 hp., the higher horsepower being confined to the smaller ratios. The sets are available for motor speeds up to 1,800 r.p.m. in the lower horsepowers and up to 900 to 1,200 r.p.m. in the higher horsepowers.



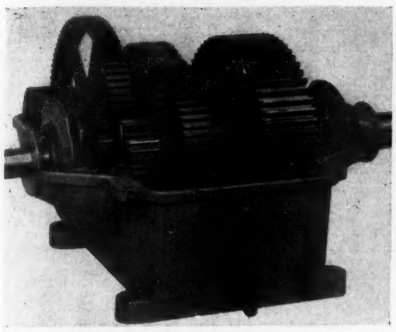
The gear arrangement in a non-planetary type of reducer.

As in the planetary type, the small, high-speed pinion *A* makes a three-point contact with three intermediate gears *B*. These, in turn, mesh with an internal gear *C*. In the non-planetary type, however, the intermediate gears *B* are journaled in the frame and the internal gear *C* is free to move because it is integral with or keyed to the low-speed shaft. For high ratios, series combinations may be used, with partitions between each stage; the intermediate gears are journaled in these partitions.

A De Laval helical gear speed reducer with the cover removed to show the gear and bearings.

The horsepower ratings given to the sets by the manufacturers are rather nominal and are not a definite measure of capacity. Generally, the ratings are based on favorable, uniform load conditions. For severe service where subject to shock or reversal of rotation it is well to discount the ratings 25 to 50 per cent, depending upon the severity and the continuity of service.

Ordinarily all types of these gear sets are direct coupled both to the motor and to the driven machine. The use of flexible couplings for these connections is practically always advisable. Also, a rigid foundation is always advisable, and practically all manufacturers will supply cast-iron bed plates for the motor



An example of the mill type or parallel shaft speed reducer.

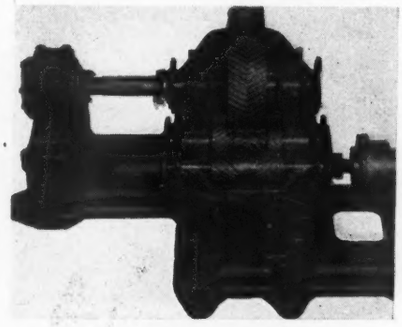
This is a Palmer-Bee mill-type unit with multiple reduction. The high-speed shaft is at the left and the slow-speed shaft at the right.

and the reducer. Where speed reducers are not direct coupled, but drive or are driven by belt or chain, outboard bearings may be needed.

The efficiency of a spur gear reducer set depends upon many details of design. Particularly well-constructed sets, including those equipped with ball or roller bearings and herringbone gears, have materially higher efficiencies than the ordinary commercial sets.

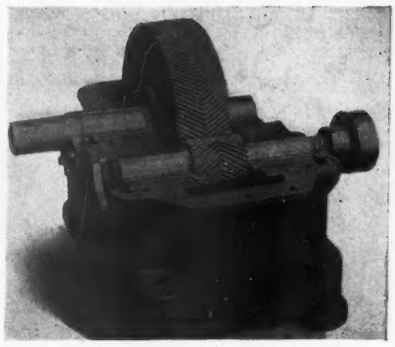
Herringbone gears are now extensively used for the larger motors and more severe service as well as for high-speed work. They offer the advantage of continuous and smooth action and largely eliminate backlash. As a result of the continuous tooth contact, which eliminates shock, and also since the teeth are stronger because of their angular position, the pitch required for any given conditions can be much finer than would be chosen for spur gears. Smaller pinions, too, may be used and therefore higher ratios can be obtained in a single reduction. It is desirable, however, to maintain sufficient pitch-line speed to restrict required tooth pressures. Gears of this type are relatively quiet.

Although herringbone gearing is sometimes used in a manner similar to spur gearing, with the pinion mounted directly on the motor shaft, this type of gear is used more commonly in a gear reduction set. When the pinion is mounted on the motor shaft, particular care must be exercised to align the gear with the rotor in its magnetic central (center) position. Even with this precaution it is difficult to obtain and maintain the accurate alignment desirable for best operation of this type of gearing as a motor pinion.



Herringbone double reduction unit with the gear cover removed.

The entire unit, including the motor, is mounted on a cast-iron bed plate; the motor is connected through the flexible coupling at the right. This is a Falk reducer. An outboard bearing is provided on the low-speed shaft, for pulley, sprocket or gear connection.



This is a Farrel single-reduction, Sykes herringbone speed reducer.

Herringbone gear sets are commonly of the parallel-shaft type. Typical units are shown in accompanying illustrations. Ratios up to about 18 : 1 may be obtained in a single reduction; standard double-reduction sets afford ratios up to about 50 : 1 and ratios up to 250 : 1 are obtainable in multiple units. Usually the gearing is incased and operated in an oil bath. The quality and the level of the oil are important factors. In the larger sets, oil-circulating systems are often used.

These units have high efficiencies; the single-reduction units have efficiencies up to 98 per cent and double reduction units have efficiencies up to 95 per cent.

The use of a flexible coupling between the motor and a herringbone gear set is advised, particularly to relieve the pinion of any end thrust.

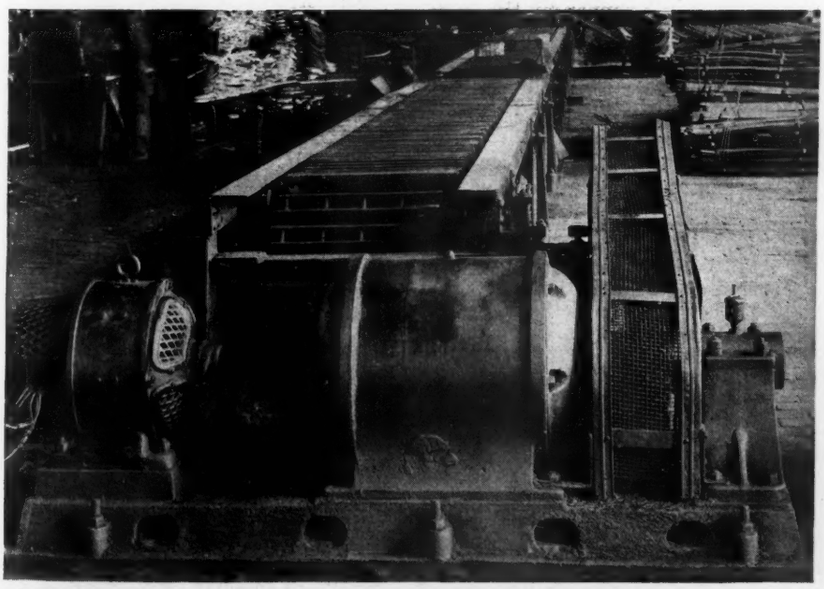
Helical gear reducers may be used for low ratios of reduction, approximately up to 5 : 1. This gear has many of the advantages of the herringbone gear and is materially cheaper. It causes a definite end thrust, however, which is a limitation.

Another article to appear in an early issue will take up worm-reduction units and variable-speed drives.

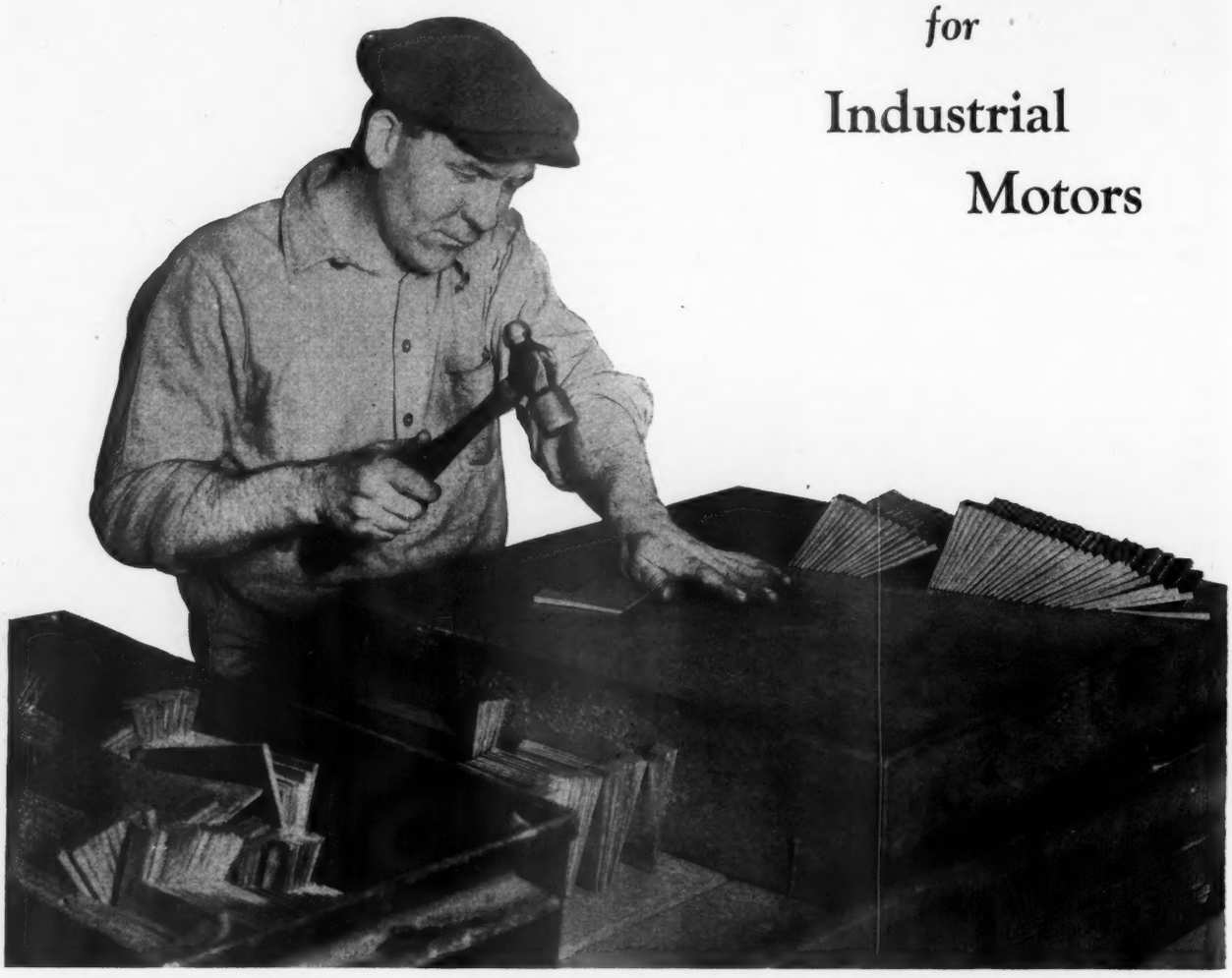
EDITORS' NOTE: Acknowledgment is made to the following companies for illustrations and information used in the preparation of this article: Albaugh-Dover Mfg. Co., Chicago, Ill.; DeLaval Steam Turbine Co., Trenton, N. J.; The Falk Corp., Milwaukee, Wis.; Fawcus Machine Co., Pittsburgh, Pa.; Foote Bros. Gear & Machine Co., Chicago, Ill.; Wm. Ganschow Co., Chicago, Ill.; The Hill Clutch Machine & Foundry Co., Cleveland, Ohio; D. O. James Mfg. Co., Chicago, Ill.; Palmer-Bee Co., Detroit, Mich.; and Philadelphia Gear Works, Philadelphia, Pa.

This coil conveyor is driven by a chain from the low-speed shaft of a spur-gear speed reducer.

Here a 5-hp., 500-1,500-r.p.m. variable-speed motor drives the Jones reducer that has a reduction ratio of 125.4 : 1. Because of the overhung load on the chain drive, an outboard bearing is used.



Selecting Commutator Bars for Industrial Motors



By JESSE M. ZIMMERMAN
Renewal Parts Engineer, Westinghouse Electric & Mfg. Company, Pittsburgh, Pa.

A COMMON trouble experienced with commutator bars is what is known as copper sickness. This trouble can be avoided as has been brought out by Mr. Piling in an article published in *Electric Journal* for August, 1920. Commercial copper has a small percentage of oxygen in the form of copper oxide. Without oxygen, copper has poor mechanical characteristics. It should not be heated in a gas flame if it is at all possible to heat it in any other manner, and never in a flame which is rich in free hydrogen because the hydrogen unites with the oxygen in the copper, producing water in the form of steam. Hydrogen readily enters hot copper, but the steam produced cannot escape. This causes the copper to be not only weakened by the loss of its oxygen, but also results in the expansion of the copper by the high-pressure steam. This makes the copper spongy and still weaker. The effect is greater near the surface which is directly exposed to the flame.

Workmen can avoid "sick copper" by not heating commutators with a flame played directly on the copper. If it is absolutely necessary to heat a commutator by applying the flame directly on the copper, it should be out of the inner cone of the blue flame. If a gas and air torch or furnace is used for heating copper, an excessive amount of air should always be used, as too little air will produce an excess of free hydrogen. Smoke from such a torch is always an indication of too little air. The mixer should be adjusted to give a little more air than is necessary to prevent any trace of smoke.

The electric conductivities of metals and their alloys bear a fairly close relation to their heat conductivities. Through extensive tests, it has been found that very little impurity in copper will reduce the

THIS is the second article of a series on the selection of the materials and the methods used in building and repairing commutators. The first article, which appeared in the December, 1926, issue, dealt with the selection of mica. In the present article the selection and use of copper for commutator bars are considered. The third article, which will appear in an early issue, will discuss the assembly of commutators.

Straightening the copper bars before assembling them in the commutator.

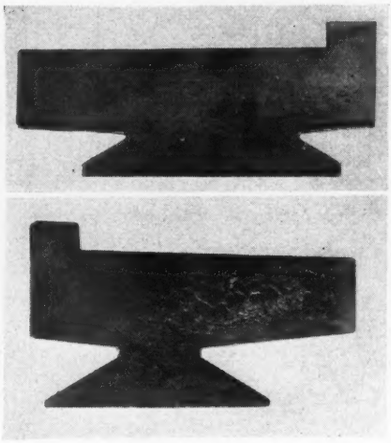
conductivity to possibly one-third. Most of the alloys of copper have very low heat conducting properties compared with those of pure copper. Silver has a lower heat conductivity than copper alloy. Accordingly, a commutator made of silver should give the best commutation. It does, but is not available as it is too expensive for this use.

Anything which tends to increase the heat-conducting properties of a commutator will tend to decrease the burning action. This has been clearly demonstrated in an elaborate test of carbon brushes on a collector ring, where the question of commutation could not disturb the conclusion. Such tests were made on cast iron, wrought iron, bronze, various alloys including cast copper, and pure copper. With high current densities, the burning and blistering action appears to be dependent upon the ability of the metal to conduct the heat from the contact surface. The fusion of the metal on good heat-conducting materials will be so small that the polishing action of the brush will keep the surface in a smooth, glossy condition. Some of the older types of alternating-current motors use collector rings made from cast iron and steel because of the low current density.

In the course of the development of commutating machinery, silver, pure copper, both hard and soft, various copper alloys and brasses, cast copper of various purities, aluminum, wrought iron and even cast iron have been tried. Experience has shown that all of them can be used in commutators if one is willing to pay for the high price of maintenance and unsatisfactory operating characteristics plus a higher first cost, because the use of any other metal than pure copper or silver will mean a larger commutator. This in turn will mean an increase in size of the machine.

An experimental commutator was made with iron bars. The commutator soon developed high mica, and the commutating surface became blackened and blistered. Sparking gradually increased until commutation reached a state where it was impossible to operate the motor. High mica was not caused by the metal wearing faster than the mica. It was caused by the contact surfaces burning away, leaving high mica.

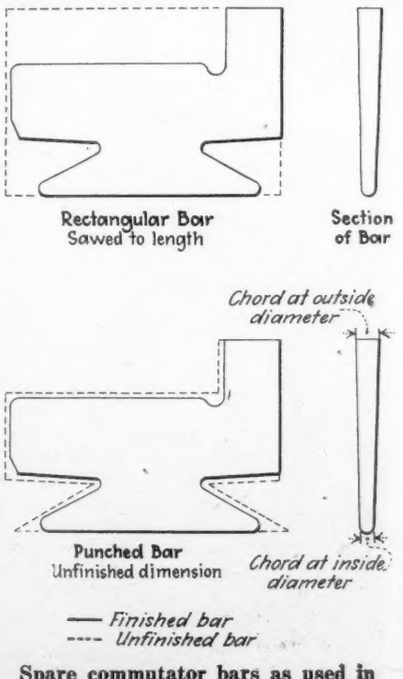
Aluminum was also tried. It worked better than iron, in that burning, blackening and high mica did not appear so quickly. However, like iron, it did not take a polish and soon had a dull appearance, which gradually turned black and burned badly. The high resistance of the aluminum oxide which formed on the surface due to sparking, and the high mica caused by the burning of the contact surface, increased the contact resistance.



These illustrations show the difference between cast copper and hard-drawn copper commutator bars.

The bottom illustration shows a cast copper bar. Note the round edges and sand holes left in the bar.

Bronze, brass, cast copper, and copper alloy were tried for commutator work. While they gave better results than aluminum or iron, the commutator would develop high mica more quickly than those built of hard-drawn copper made from pure copper ingot metal. This burning action is a function of the contact resistance, current density, and the non-burning and non-blistering qualities of the metal used in the commutator.



Spare commutator bars as used in production, and as supplied for repair purposes.

The use of copper alloy, which costs almost as much as hard-drawn copper, does not warrant the increased cost of maintenance and interruption of service. Furthermore, if a commutator having copper alloy bars whose conductivity ranges from 50 to 60 per cent is substituted for a commutator made of pure copper and which is working at its maximum temperature, it certainly will be overheated.

Copper can be cast in sand molds, but difficulty is encountered in the formation of blowholes, which are caused by the pocketing of the gas during cooling. An example of this is shown at the top of this page. It is also very difficult to control the conductivity of cast copper. Some of the copper bars may have a high conductivity, while other bars may have a very low conductivity. For this reason many manufacturers will not sell cast copper material under a contract that it will have more than 75 per cent conductivity.

In the Question and Answer department of the June, 1926, issue of INDUSTRIAL ENGINEER the merits of cast copper versus hard-drawn copper were thoroughly discussed. The following brief summary of these discussions will show the operating man's viewpoint:

"Cast copper commutators are a continual source of trouble."

"Soft and hard places result in uneven wear, making it necessary to turn the commutator once every month."

"Had to clean out between bars every day or so. Only one thing can be truthfully said in favor of cast commutators—the price is cheaper than that of hard drawn copper."

"When through wear a sand hole or spongy part is exposed on the contact surface, trouble begins."

"Cast copper is of very low grade and is likely to be porous. Its wearing qualities are from 75 to 90 per cent of those of hard-drawn copper."

"Pores in cast copper fill up with carbon dust off the brushes and cause heating."

"When one considers that cast copper has 20 per cent less conductivity the heating becomes quite an item."

"It has been my experience that the operating man who pays atten-

tion to the advice of the motor manufacturer has the least trouble and expense. The motor manufacturer's organization and integrity are founded on years of experience and at a considerable cost in trying to put out the best product possible; so when the motor manufacturer advises the use of good copper for commutators, he speaks from a background of experience in manufacturing and repairing them."

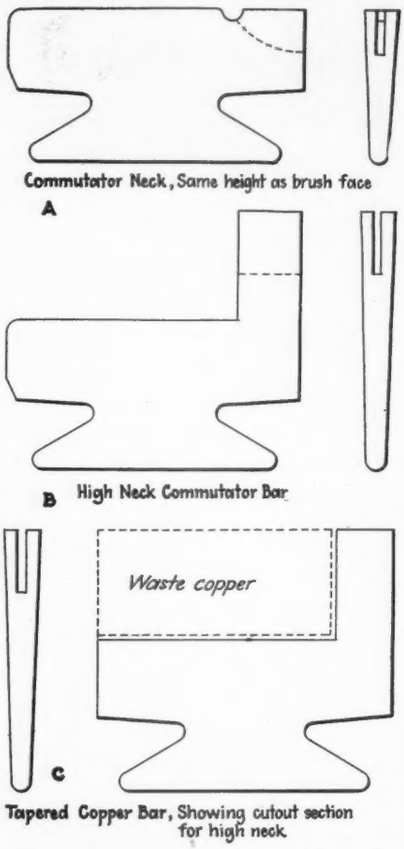
From the foregoing remarks, it is evident that copper bars to be used in renewing a commutator should be of same material and workmanship as the original copper bars. Purity is one of the important points worthy of consideration.

The copper bars should be made from pure, hard-drawn copper whose conductivity is not less than 98 per cent, 100 per cent being based on copper having a resistance of 9.59 ohms per mil-foot at 0 deg. C.

Hardness should also receive due consideration. The copper bars should be made of hard-drawn copper, having a Brinell hardness number of not less than 75. They should be able to withstand a fiber strain of 25,000 lb. per sq.in. in order to overcome the stresses due to centrifugal force of rotation and stresses caused by alternate heating and cooling of the commutator while in service. The Brinell hardness number for cast copper bars which are afterward cold pressed to size is from 50 to 55. Soft copper has a Brinell hardness number of 38 to 40. From this it can be seen that the hard-drawing process will produce better commutator copper than the other method.

The die, through which the copper is drawn, is called a section. The opening in the die conforms with the cross-section of the bar, as shown in the drawing on page 169. During the drawing process, samples are taken for chemical analysis, hardness test and gaging of the section. Gaging is a frequent operation to see that the size of the bar remains uniform. In the manufacture of high-grade commutators there are certain specifications which the bars must meet. Some of these specifications prescribe certain limitations, which are listed as follows:

(1) The copper bar must not vary from the specified section at either drawn edge by more than plus or minus .001 in. The algebraic difference at the two drawn edges must not exceed 1 mil. If this variation is not adhered to, the distance from any bar to the corresponding bar under the next pole may vary more than plus or minus 1/32 in. If this variation is larger or smaller, sparking will be prevalent at these spots. This is equivalent to increasing or decreasing the width of the commutating zone while the brush setting remains constant. Consequently, when a wider or narrower commutating zone passes under the brushes, they must short-circuit bars connected to coils whose potential is not zero. Therefore, sparking will be prevalent at these points.



These are types of solid-neck commutator bars.

(2) The concavity of each surface of the copper bars must not vary more than 1 mil from the computed thickness; that is, the gaged thickness at any point must not be more than .002 in. less than the computed thickness.

(3) The convexity of the surface of the copper bars must not vary more than .0005 in.

(4) All bars should have a drawn radius at the bottom chord. When a 1/32-in. mica extension is allowed in the bore, the combination of the two will give a large creepage between bars. On some motors the space between the bore of the assembled segments and the commutator spider is so small that it is necessary to machine the bore of the assembled segments. In such cases the drawn radius is of no value.

(5) All commutator bars should be chemically cleaned to remove all grease and dirt as is illustrated below.

(6) All commutator bars should

Cleaning bath in which the individual bars are dipped to remove all dirt and grease.

be free from roughness, cracks and laminations.

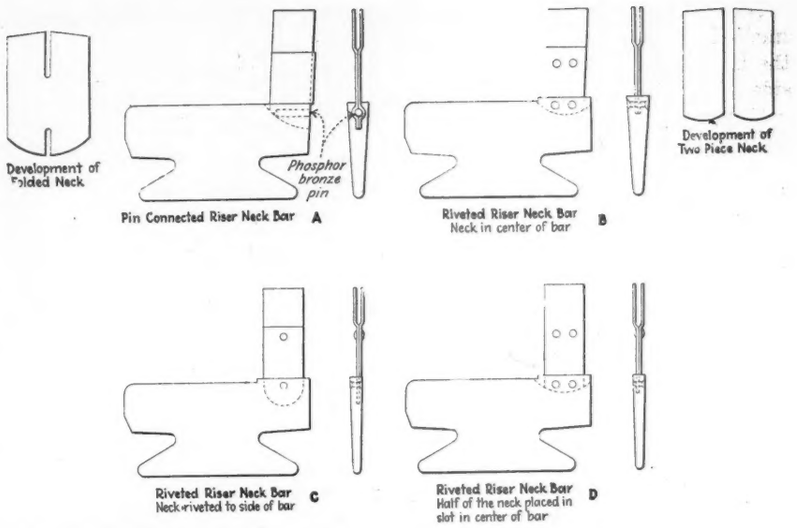
Commutator bars may be divided into two classes: namely, bars with solid necks, and bars with riser necks. The commutator neck is that part of the bar in which the leads are soldered.

Commutators which have the necks as an integral part of the bar are called solid neck commutators. The neck may stand several inches above the brush face, or it may be the same height as the brush face, as shown at *A* and *B* in the drawing on page 170. The neck is obtained by making a solid, tapered bar the same width as the bar and the neck. If the bar has a high neck the copper shown above the dotted line is cut out as is shown at *C* in the drawing on page 170.

This solid type of neck has advantages in that the necks being part of the bar no trouble is experienced from broken necks and, since the necks form a solid arch, no vibration is present to cause breakage.

Commutators which have the necks mechanically fastened to the copper bar are called riser neck commutators. There are two standard methods of connecting these necks to the bars: namely, "pin connected" and "riveted neck."

The pin-connected neck is used on commutators whenever it is possible, due to the simplicity of assembling. It consists of a folded neck and a phosphor bronze pin. You will notice in diagram *A* on this page that the neck is formed with a hole for the pin. The copper bars and mica strips are assembled and machined, after which a hole is drilled in the rear of each bar on the center line a definite distance below the top brush face. The depth of the hole depends on the width of the neck. After the hole is drilled the bars are slotted slightly wider than the width of the neck, and in the center. The depth and the radius of the bottom of the slot must conform with the design of the neck. The neck is then driven into the slot, the expanded place for the pin fitting into the drilled hole. The neck is expanded by driving a phosphor bronze pin into the hole, thereby holding it in place. In order to make a better electrical contact the necks, which are tinned before they are assembled, are soldered with pure tin solder at the rear of the commutator. A machine cut across the rear of the segments removes any excess solder and makes a smooth, finished surface.

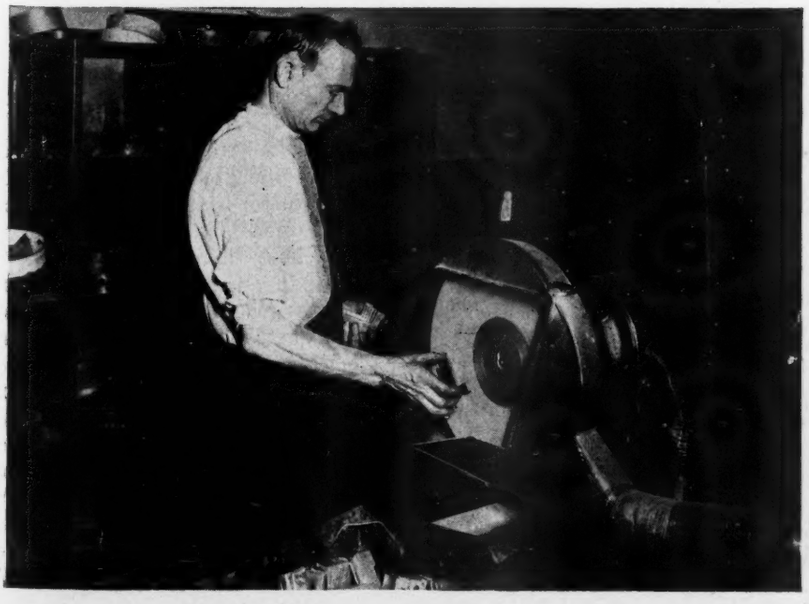

Development of Folded Neck
Phosphor bronze pin
Pin Connected Riser Neck Bar A
Riveted Riser Neck Bar
Neck in center of bar B
Development of Two Piece Neck
Riveted Riser Neck Bar
Neck riveted to side of bar C
Riveted Riser Neck Bar
Half of the neck placed in slot in center of bar D

Here are four types of riser-neck commutator bars.

The pin application of the connected neck is limited to commutators having a medium length brush face and diameter, provided the wall thickness is not less than the thickness of the mica strip. When the pin-connected necks cannot be applied, the rivet-connected type is used.

Rivet-connected necks have three different applications, depending upon the width of bar. When the bar is thick enough each bar is individually slotted in the center, wide enough for a folded neck or a double neck. The wall thickness must not be less than the thickness of the mica strip and the slot must be as nearly a half moon as possible, the radius being the same as that of the neck which must enter the slot as shown at *B* in the diagram above.

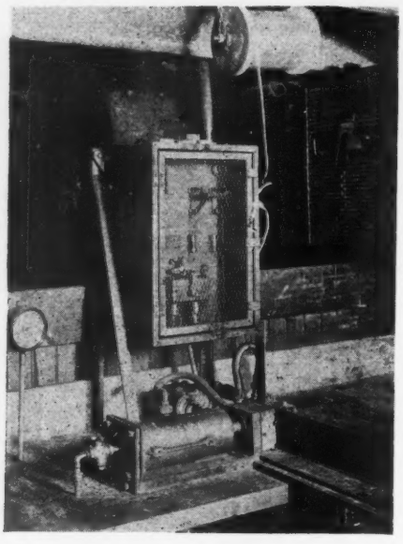
This shapes the slot so that it will hold the solder during the soldering operation, which is very important. After the bar is slotted the neck, which has been tinned, is placed in the slot and held in alignment with a special fixture while the two holes are marked with a center punch. This holds the necks in place while the holes are drilled. The neck is mechanically sustained by two soft copper rivets and soldered by heating the bar between two electrodes with electric current as shown in the illustration on page 172. When no electric heating device is available it is necessary to heat the bars by placing them between the two gas flame jets. Extreme care must be exercised when using a gas flame to prevent "sick copper," as previously explained.



Removing the burrs from both sides of the individual copper bars by grinding.

When the wall thickness is too small for a central slot to contain the two thicknesses of the neck, the side of the bar is slotted with an end mill as shown in *C* of the diagram on page 171. The neck is drilled while in the slot. It is then held to the bar by a soft copper rivet, after which it is heated by electric current between two electrodes and soldered. The wall thickness must not be less than twice the thickness of a mica strip.

Some bars are so thin that even the side slot method of fastening will not accommodate the two thicknesses of the neck. In such cases the bar is slotted in the center for the one side of the neck only. The other half of the neck does not enter the bar.



Electric heating device for soldering riser-neck commutator bars.

The air cylinder furnishes sufficient pressure for the low voltage to force enough current through the bar to heat it. The carbon contacts are water cooled. This permits quick chilling of the solder after the bar has been soldered.

This type of neck is used for very light service. The neck is held to the bar by a soft copper rivet, and soldered. This method is illustrated at *D* in the diagram on page 171.

All riser necks should be soldered with pure tin solder, the necks being tinned before soldering. Should the neck be soldered in a gas flame, the part of the neck which receives the heat must be retinned if the flame leaves the surface greasy, as this will make it very difficult to solder the armature leads.

Repair bars for riser neck commutators should be ordered from the factory with the neck assembled. However, a supply of riser necks may be carried on hand in case any should be broken.

Where a large number of bars of a given size are used, a punching die is employed to punch the bars to an unfinished size; that is, the V's are punched leaving $\frac{1}{32}$ in. for finishing. All repair bars for these commutators are supplied in this manner when a die is available.

On a great many motors, however, the number of bars of given size is so small that it is cheaper to machine the V's from the rectangular bars after they are assembled, than it is to make a punching die. These bars are sawed into lengths corresponding to the unfinished bars, as shown in the drawing on page 169. These unfinished bars are called rectangular bars. For repair purposes rectangular bars should have the V's rough sawed, leaving $\frac{1}{8}$ in. of material for finishing. Most bars for riser neck commutators are made from rectangular bars.

The following instructions describe the proper method of replacing damaged bars:

(1) Remove the damaged bars; use an undamaged adjacent bar for a pattern.

(2) Cut a new mica strip to the same size as the unfinished bar.

(3) Stick the mica strip to the copper with a thin coat of heavy, pure, orange shellac.

(4) Clamp the unfinished bar in a vise with a pattern bar.

(5) Trim it to approximately the outline of the pattern. If the V's have been rough sawed or punched, the amount of filing may be reduced by taking an extra cut with a hacksaw.

(6) Clamp the unfinished bar and the pattern in a vise with a mica strip between them. File the V's of the new bar to the same size as the pattern bar. The radius in the V's can be finished with a small rat-tail file. The bars are then ready to be placed in the commutator.

(7) Re-assemble the commutator, making certain that all the bars and the V-rings are in their proper places, and turn the commutator nut fairly tight.

(8) Heat the commutator to 125 deg. C. in an oven for several hours. While the commutator is still hot, apply a pressure of 20 to 30 tons to the V-ring and turn the commutator nut home. The method of assembling will be discussed later.

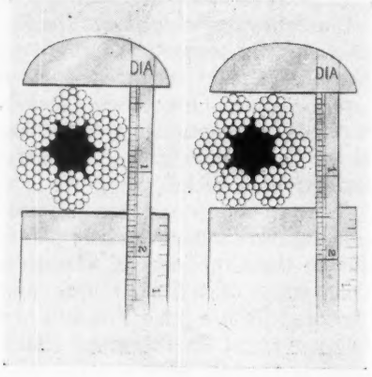
(9) Test for loose bars. A good method of testing for loose bars is to tap on the face of the bars at the front and rear. If a bar is loose, it will vibrate.

(10) Solder the leads in the commutator slots, turn the face of commutator and undercut the mica. Test for grounds and short-circuits.

Correct Method of Measuring Size of Wire Rope

THERE is only one way to measure wire rope correctly, and that is shown in contrast to the incorrect method, by the accompanying illustration furnished through the courtesy of the American Cable Co. The sketch at the left shows the correct method of measuring wire rope, as the greatest diameter determines the size.

It is highly important that the proper size of rope be employed, since an undersized rope will not give the degree of service that should reasonably be expected, while an oversized rope represents needless investment

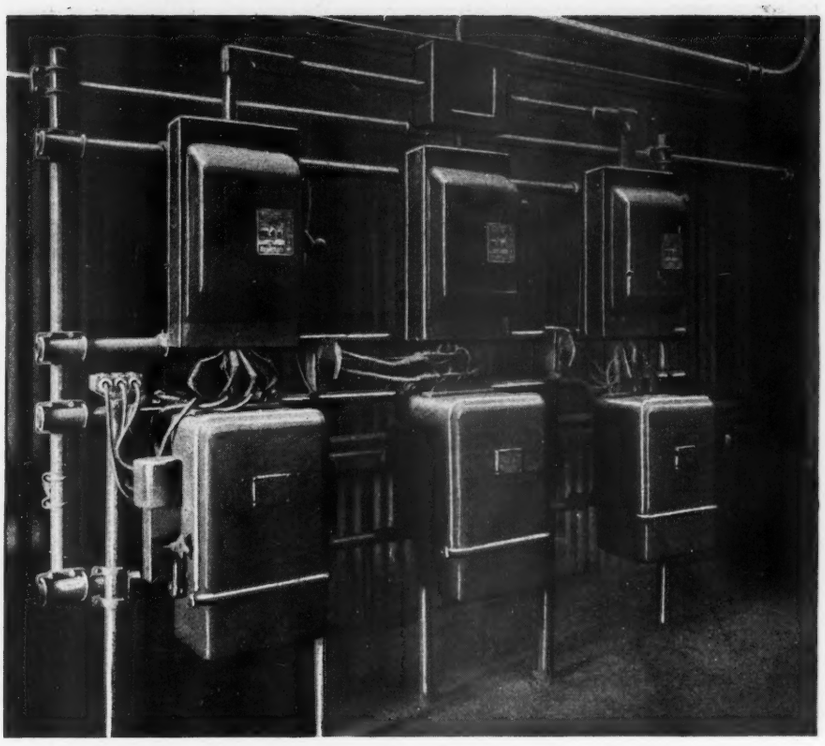


This shows the correct and the incorrect method of measuring wire rope.

and will not properly operate over sheaves grooved for smaller ropes.

It is more important, however, to have the rope and the sheave properly fitted. No wire rope should be allowed to travel over a sheave wherein the groove is too small for its diameter. A pinching sheave will do more damage to a wire rope in one hour than a properly grooved sheave in an entire week, or more. Sheaves grooved $\frac{1}{32}$ in. larger than the diameter of the rope will lengthen the life of the rope many times, as compared with rope life on pinching sheaves.

Since sheaves are cheaper than good wire rope, there is small economy in continuing the operation of improperly grooved sheaves or drums. Also the tread diameter of a sheave greatly affects rope life.



Mounting compensators on a pipe framework in this way facilitates inspection and repairs.

There is plenty of room to work on any switch or starter and any one of these units can be repaired or removed without disturbing the others.

Routine for Inspection of Starting Compensators

By J. ELMER HOUSLEY

Electrical Engineer, Aluminum Co. of America, Alcoa, Tenn.

IT IS SOMETIMES felt that a rugged piece of equipment, such as a motor starting compensator, that does not have any continuously rotating parts may be practically forgotten insofar as maintenance attention is concerned, but such devices almost always have an unpleasant way of calling attention to themselves under such conditions. Maintenance records covering many years indicate that about 60 per cent of compensator failures may be traced to bad contacts and bad oil, and about 30 per cent to insulation failure on the terminal and finger supports. The remaining 10 per cent of failures are caused by miscellaneous defects. Obviously, these percentages will hold only for the plant surveyed, and will vary according to the nature of the processes and the service requirements. The inherent possibility of each kind of trouble is present, nevertheless, in nearly every industrial plant.

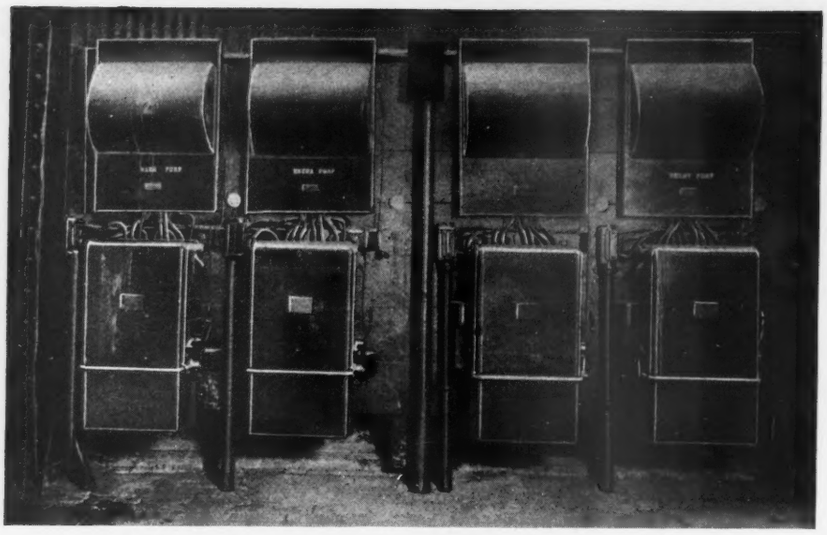
Frequently the construction and operation of the compensator are not understood by the plant maintenance men, and the equipment suffers thereby. It may be well, then, to say that the essential parts are two sets of stationary contacts and a movable element that makes contact with the stationary contacts. The function of a compensator is to start the motor on low voltage. It does this by first connecting the motor winding with an auto-transformer which is generally tapped to give starting voltages ranging from 40 to 75 per cent of line potential. After the motor comes up to speed the auto-transformer is disconnected from both the line and the motor and the latter is connected directly to the mains either through fuses or overload relays. The starting current is often taken directly from the mains without any form of overload protection during the starting period. This is the most satisfactory method.

Prior to 1922, treated maple was used for the wooden terminal blocks in compensators and the stationary contact fingers and movable contacts were secured to the maple blocks; flexible copper strips extended from the movable contacts to the stationary center terminal. The later designs of compensators use insulated steel rods for carrying the various contacts.

After a certain period of operation the contacts and fingers become pitted and burned, which tends to make poor contact. This may in turn overheat the wood or insulating material and cause a failure, and the oil becomes carbonized. In some cases single-phase operation occurs because of a burned contact on the running side; if the fuses are large a burned-out motor may be the result. Furthermore, the resultant bad condition of the oil may cause a short-circuit to the oil pan. This will burn a hole in the pan and may throw blazing oil over surrounding objects.

The second group of failures, caused by insulation breakdown between phases across the contact terminal board, may be ascribed to dirt, dust, conducting materials and water in the oil (collected during cold weather by condensation inside the steel case). All of this material gathers on the terminal strips and the resultant leakage current carbonizes the wood or insulating material until an arc may be maintained, which then becomes a destructive short-circuit. The necessity of periodic inspection has, therefore, a sound basis, as established in the foregoing discussion.

Although this discussion is not primarily concerned with the methods



In this case inspection and repair work are hampered by the manner in which the compensators and switches are mounted.

These units are mounted on boards. The oil pans of the compensators are too close to the floor and too close to the boards.

of mounting compensators, it may not be out of place to say that when such equipment is installed care should be taken to see that it is easily accessible for inspection and repair. A little forethought and planning at this time may save a good deal of inconvenience later on. One of the accompanying illustrations shows an installation in which some details of this nature were overlooked, with the result that the equipment is hard to get at for inspection.

The selection of the proper interval between inspections and the season of the year to make the inspection depends upon the operating conditions, the temperature exposure, and the duty cycle. A well-designed compensator operating under severe conditions should not require examination oftener than once in six months. For compensators in light service an examination once a year should suffice. The reason for indicating the proper season for inspection applies chiefly to compensators exposed to rapid and extreme temperature changes, whereby moisture that collects in the oil may freeze the mechanism and render it inoperative. From a protective standpoint the yearly inspection in this case should be made during the middle of the winter, and another one in the spring may be necessary.

The routine of inspection should comprise the filing or dressing of pitted contacts to put them in proper condition, and the replacement of thin or defective contacts. The oil should be changed once a year if it is dirty or carbonized. If the oil is clean and free from water it should be given a potential breakdown test, in cases where the operating voltage is above 440 volts. The oil should be removed and filtered if it tests below 22,000 volts, 30,000 volts being the optimum breakdown voltage with the test cup generally used. The oil pan should be cleaned and dried. All insulation should be examined for evidences of leakage current and should be cleaned. All terminals, studs and nuts should be carefully tightened to eliminate loose or hot contacts. The operating levers and mechanism should be cleaned and tested for proper and easy operation. Relays should be cleaned and worked by hand to make sure that they are in good condition. If fuses are used they should be examined and the contacts cleaned.

After reassembling, the compensator should be tested and the action of the low-voltage release observed. It should be put into good operating condition if it is found to be sluggish.

After having experienced the benefits that are to be derived from a routine annual inspection the maintenance crew of a plant could hardly be persuaded to return to the old method of waiting until the compensator blows up before looking at it.

Cutting Cost of Operating and Maintaining Lighting Systems

THE article by O. C. Callow in the February issue of INDUSTRIAL ENGINEER should be of interest to all industrial executives and engineers. It is of special interest to us, due to the fact that we recently discontinued the use of 110-volt lamps in part of our plant and are now using 115-volt lamps. This has resulted in quite a decrease in the total number of lamps used in the departments where this change was made.

After reading articles showing where production has been increased as much as 25 per cent by improving lighting equipment and increasing the intensity of the light, and articles showing where 18 per cent of all industrial accidents are due to poor lighting, it is easy to realize that the cost of artificial illumination is small compared with its importance in production and safety to workmen. Therefore, before we try to make a small saving in our lighting cost, we should be sure that we are really going to make a saving and that we are not sacrificing one thing for another.

The function of a lighting system is to produce an intensity of illumination of the correct amount and quality on the working plane. The efficiency or cost of a lighting system should be the cost per foot-candle of light or per lumen, for a given length of time. In checking the efficiency or cost of a lighting system all of the following factors should be considered:

(1) Intensity or amount of light.
(2) Cost of power.
(3) Cost of lamps.
(4) Cost of maintaining system, replacing lamps, cleaning equipment, etc.

It would no doubt greatly interest your readers to know what intensity Mr. Callow had on the working plane when he was using 115-volt lamps and what intensity he has now when using the 120-volt lamps. Also, what his maximum demand and cost of power were in both cases, and what his minimum, maximum and average voltage at the lamp is.

To check the saving that Mr. Callow made, I have taken his data and calculated the cost per lumen in

1924 and 1926. To do this it was necessary to make some assumptions. If they are incorrect or if I have made any mistakes, I shall be glad to have the correct data.

In making the following calculations I assume that the 250-volt lamps operated are on a.c. circuits, although it may be that all the 250-volt lamps are operated on a d.c. circuit. However, the following figures are about right, as the kilowatt-hours and lumens for the 250-volt lamps are about the same for both years. The main difference is the change from 115-volt lamps to 120-volt lamps.

Since Mr. Callow stated that there was a tendency for the voltage to rise to 118 volts at certain times of the day, I assumed the average voltage to be 116 volts on the 115- and 120-volt lamps, and 232 volts on the 250-volt lamps. I also assumed the average size of all lamps to be 130 watt. For 1924 only the total number of lamps installed is given, making it necessary to assume that 1,200 are 115-volt lamps and that 162 are 250-volt lamps.

The cost per lumen for 1924 was calculated as follows:

Connected load: 156 kw. of 115-volt lamps and 21 kw. of 250-volt lamps.
Demand: 158 kw. of 115-volt lamps and 18.7 kw. of 250-volt lamps.

The demand does not equal the connected load due to the fact that the line voltage is not equal to the rated voltage of the lamp; that is, 116 volts on the 115-volt lamps would increase the input to the lamps, whereas 232 volts on the 250-volt lamps would decrease the input to the lamp. Then we have:

Total demand, 176.7 kw.
Kilowatt-hours used per year ($10 \times 365 \times 176.7$), 645,000.
Cost of power per year ($\$0.01 \times 645{,}000$), $6,450.
Cost of lamps and labor for replacing, per year, $2,720.
Total rated lumens of 115-volt lamps ($1{,}900 \times 1{,}200$), 2,280,000.
Total rated lumens of 250-volt lamps ($1{,}400 \times 162$), 227,000.
Total actual lumens of 115-volt lamps ($103.3 \times 2{,}280{,}000$), 2,355,000.
Total actual lumens of 250-volt lamps ($0.77 \times 227{,}000$), 175,000.
The actual lumens do not equal the rated lumens due to line voltage not being the same as rated voltage of lamp.
Total lumens, 2,530,000.
Total cost, $9,170.
Cost per lumen per year, $0.00363.

The cost for 1926 was as follows:

Lamps installed: 120-volt lamps, 1,295; 250-volt lamps, 161.
Connected load: 168 kw. of 120-volt lamps and 21 kw. of 250-volt lamps.
Demand: 161 kw. of 120-volt lamps and 19 kw. of 250-volt lamps.
Total demand, 180 kw. Kilowatt-hours used per year, 657,000.
Cost of power per year, $6,570.
Cost of lamps and labor of replacing them, $1,800.
Total rated lumens of 120-volt lamps, 2,460,000 and of 250-volt lamps, 225,000.
Total actual lumens of 120-volt lamps, 2,165,000 and of 250-volt lamps, 171,000.
Total actual lumens, 2,336,000.
Total cost, $8,370.
Cost per lumen per year, $0.00358.

Although Mr. Callow shows a saving of 38 per cent in the total cost of lamps and replacement of lamps, the above figures show that he is saving only about 2 per cent in the cost of lighting his plant. If the loss due to burning the lamps 1,400 hours instead of 1,000 hours could be calculated, I believe that we could show that Mr. Callow paid more for his light in 1926 that in 1924. Also the losses that cannot be figured are decrease in production and possible injury to workmen due to the fact that the intensity on the working plane was decreased about 15 per cent when the 115-volt lamps were replaced with 120-volt lamps.

To get the maximum efficiency out of a lighting system the line voltage should equal the lamp voltage, which would result in an average lamp life of 1,000 hours if all lamp failures were due to burning out.

The data in Mr. Callow's article show that he was getting about maximum efficiency out of his lighting system in 1924 due to the fact that average lamp life during that year was about 1,000 hours. For efficient operation in 1926 Mr. Callow should have used about 5,314 lamps having an average life of 1,000 hours instead of 3,795 lamps having an average life of 1,400 hours, providing no lamps were broken or stolen.

All plants have special problems and difficulties that must be solved and overcome. If this was the case with Mr. Callow, he may have other good reasons for changing from 115- to 120-volt lamps. If the saving in cost of lamps used was his only reason for making the change, the loss in efficiency due to lamps burning 1,400 hours, the loss in production and possible loss due to injury will just about equal what he saves in the cost of lamps.

I believe that articles like Mr. Callow's are a great help to anyone interested in efficient plant operation, and I am sure that all the readers of INDUSTRIAL ENGINEER would be pleased to see more articles of a similar nature.

G. R. KILBOURN.
Chief Electrician,
Marion Steam Shovel Co.,
Marion, Ohio.

* * * * *

MR. KILBOURN'S remarks regarding my article in the February issue of INDUSTRIAL ENGINEER, are very interesting, especially his method of calculating the cost of a lighting system in lumens per year.

Inasmuch as he has made several assumptions in his calculations that are not correct in this instance, I have worked out the cost per lumen per year for 1924 and 1926 from the figures I have available and will also answer the several questions he sets forth.

In the first place, I wish to say that the figures given in my article are taken from the lighting costs of a blast furnace and coke plant. As anybody familiar with these types of plants will know, there is little if any fine work involved where the intensity of illumination is high. In our machine shop and electric shop the intensity is about 4 foot-candles, and in the power house about 3; the remmainder of the lighting is in conveyors, around furnaces, cast house and stoves, boiler house, pig machine, ore bridge and yard coke battery, and general outside lighting.

No change has been noticed in the intensity since the lamps have been changed from 115 to 120 volts. Furthermore, our records of personal injury have shown a decrease in the last two years and our production of pig iron has certainly not been decreased owing to the economies made in our lighting system.

With reference to the following calculation, I would say that the average a.c. voltage on the 120-volt lamps is 117, and the average d.c. voltage on the 260-volt lamps is 255.

Inasmuch as power is produced from byproducts, coke-oven and blast-furnace gas, coke breeze, tar, etc., in the plant, I have cut in half the figure used by Mr. Kilbourn in his calculation for the cost of power.

In order to make a better comparison between the cost of lighting the plant in 1924 and 1926 I have based my calculations upon the same number of lamps installed in 1926 as in 1924, omitting the extra 94 lamps that have since been installed on new work. The comparison is

Comparison of Cost of Lighting in 1924 and 1926

For 1924

Total lamps installed	1,362
Number of 115-volt lamps	1,177
Number of 250-volt lamps	185
Connected load a.c., kilowatts	153
Connected load d.c., kilowatts	14
Total connected load, kilowatts	167
Demand of a.c. lamps, kilowatts	155.6
Demand of d.c. lamps, kilowatts	14.28
Total demand, kilowatts	169.88
Kilowatts used per year (169.88 × 365 × 10)	620,135
Cost of power per year (620,135 × $0.005)	$3,100
Rated lumens of a.c. lamps (1,177 × 1,900)	2,236,300
Rated lumens of d.c. lamps (185 × 1,400)	259,000
Actual lumens of a.c.	2,274,317
Actual lumens of d.c.	264,180
Total actual lumens	2,538,497
Total cost of power	$3,100
Total cost of replacements	$2,720
Cost of lighting system	$5,820
Cost per lumen per year	$0.00229

For 1926

(Number of lamps installed same as in 1924)

Connected load a.c., kilowatts	153
Connected load d.c., kilowatts	14
Total connected load, kilowatts	167
Demand of a.c. lamps, kilowatts	150
Demand of d.c. lamps, kilowatts	13.7
Total demand, kilowatts	163.7
Kilowatts used per year	597,505
Cost of power used	$2,987
Rated lumens of a.c. lamps	2,236,300
Rated lumens of d.c. lamps	259,000
Actual lumens of a.c. lamps	2,181,100
Actual lumens of d.c. lamps	254,080
Total actual lumens	2,435,180
Total cost of power	$2,987
Replacements, 1,362 lamps at $1.24 per outlet	$1,688
Cost of lighting system	$4,675
Cost per lumen per year	$0.00192

given in the accompanying table.

We find that with the same number of lamps installed the cost per lumen per year has decreased from $0.00229 in 1924 to $0.00192 in 1926, showing a saving of 16 per cent per lumen per year.

There is a loss of about 4 per cent of the actual lumens in 1926 owing to the use of the higher voltage lamps, but a saving of $1,145 is shown in 1926, representing 19-½ per cent.

We must not overlook the fact that the changing of the voltage on the lamps is not responsible for all of this saving, as several other improvements were made in the lighting system between 1924 and 1926, as described in my article.

I wish to thank Mr. Kilbourn for his discussion of my paper, as it is this kind of interest that brings out many points that may be overlooked or passed over in a paper.

O. C. CALLOW.

Chief Electrician,
Trumbull-Cliffs Furnace Co.,
Warren, Ohio.

Markings on Roof That Show Location of Leaks

AT A New Jersey factory manufacturing printing machinery, a series of numbers are painted on the roof. These seem odd to visitors until their purpose has been explained. The numbers correspond with the numbered posts or columns that are directly underneath, regardless of whether the building is one or more stories high. Wherever it is possible to do so, the numbers are painted upon a riser or other upright part nearby.

The purpose of this numbering is to locate leaky spots more readily. Irrespective of how good a roof may be, it is going to leak at times due to a cracked glass, a spot rusted through under the paint, a sheet of prepared roofing that has become brittle through long wear, or any of the other little things like these that let in enough water to damage valuable stock. A driving storm will find all the leaks, both large and small.

Men cannot repair leaks during a storm and often it is a day or two after a storm before it is possible to make a good repair, even if the trouble is followed up quickly.

In this plant, every post is numbered. Whenever a leak is discovered its location can be noted exactly, as for example, 12 ft. northeast of post 82. With such information the repair crew can go directly to the spot on the roof. The numbers on the roof are near enough to the posts to form as accurate a guide as is necessary. Foremen are instructed to note leaks in their departments and to report them by location.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Repairing Workbench with Minimum Interruption

THE method used to repair about 80 ft. of workbench in a machine shop, may be of interest to the man with a similar problem in some other plant. The old bench had been made of soft, yellow pine which had worn and been cut away on the surface until it was neither level nor usable, and the men were complaining of the slivers which they got into their hands. The first plan proposed was to tear out the old bench top and put in a new one. It was thought, however, that this would interfere too much with the bench hands.

Finally the foreman of the Maintenance Department noticed that the bench top appeared to be somewhat low, because the men had to stoop at their work. Therefore, instead of tearing off the old top and keeping the men from their work for some time, he suggested that the new planks be put on top of the old ones. The foreman of the department, when the low bench height was called to his attention, readily agreed to this. The old bench was 33 in. high, while 36 in. is considered a better bench height.

Accordingly, 3-in. dressed maple planks were mounted on top of the old pine planks by lag bolts screwed in from beneath. One section was done at a time; so the work of the bench hands was hardly interfered with. The cost of this job was estimated at about one-half of what had been anticipated when it was thought that the entire bench top must be removed. In addition, there is the added benefit of a more comfortable working height for the men.

What have you done with Electric Arc Welding?

Here is an opportunity to obtain recognition for your accomplishments

ONE of the finest examples of co-operation between a manufacturer and users of equipment has just come to my attention in the announcement of the Lincoln arc-welding prizes by the American Society of Mechanical Engineers. Because I feel sure that there are a number of readers of this publication who can compete for these prizes, I want to give you in brief the details of the competition and urge you to enter it if you are interested in, and have had some experience, with arc welding.

IT IS stated in the announcement that the American Society of Mechanical Engineers has accepted the custody of $17,500 offered by the Lincoln Electric Co., Cleveland, Ohio, to be awarded by the society in a world-wide competition for the best three papers disclosing advancements in the art of arc welding, that are submitted under the rules of the competition. Three prizes will be awarded; namely, $10,000, $5,000 and $2,500.

THE purpose of this competition is to encourage the art of arc welding, to point out new and wider applications of the process, to discover improved methods of testing welds, and to indicate the advantages and economies to be gained by its use. Anyone in any country of the world may compete, and about nine months are allowed for the preparation of the competing papers, as the closing date of mailing is Jan. 1, 1928.

HERE is a real and rare opportunity to work for a worth-while prize and besides play a part in a world-wide endeavor to promote a process that not only has well-recognized mechanical advantages, but the possibilities of enormous savings to industry when it is more widely applied. To be identified with a competition of this sort is a distinction to be recognized, aside from the liberal cash awards that are offered.

THINK back and review the early development work in the application of electricity, and consider the comparatively slight knowledge of the subject then possessed by even the leading authorities. Or, come closer to our own day and compare the metals and manufacturing processes of ten years ago with those now found in the modern automobile factory, for example. Then you get a picture of the opportunity that lies before anyone who can still further devise ways and means to reduce the cost of manufacturing methods and speed up manufacturing processes. In such ways and means electric welding is certain to be an important factor.

IN THE minds of those who have used electric welding, little doubt can exist that it will eventually replace riveted construction for many purposes, and make it possible to do away with many of the complicated, costly, and needlessly heavy machine frames now made of cast iron. The savings in weight, labor and material costs, combined with equal or greater mechanical advantages, will demand this progress by the force of competition alone. And so this subject is a timely one for study and specialization. Who knows but that there may arise a new profession and title of Electric Welding Engineer that will carry the same responsibilities in manufacturing industries as the Metallurgist and Chemical Engineer do in the metal-refining industries?

ASSUMING that you are looking into the future and have the inclination and ability to do pioneer development work, here is an opportunity you cannot afford to pass by. Write to the American Society of Mechanical Engineers at 29 West 39th St., New York City, and ask for a copy of the 18-page booklet outlining the conditions governing the award of the Lincoln arc-welding prizes.

Practical Pete

P.S. IF YOU are a reader of INDUSTRIAL ENGINEER and want to enter this competition but cannot decide on the best way to get data or conduct an investigation, just write me a letter and I shall be glad to give you all the help I can. I have a number of ideas right now that I should like to pass on to someone. P. P.

INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories
G. A. VAN BRUNT, *Editor*

Maintenance Work Is Coming Into Its Own

ONE of the best signs of the increasing regard which the management of industrial concerns is according to the maintenance and operating departments and their activities is the tendency to provide better quarters and equipment for them. In times past, when maintenance was looked upon somewhat as a necessary nuisance that must be tolerated because machines would break down, the maintenance department was usually housed in some out-of-the-way building, or in a dark and dreary section of the plant that was least adaptable to manufacturing, and for equipment often had to depend upon machinery cast off from the production departments.

In visiting maintenance and operating departments, one is impressed with the number of instances where they occupy ample space in bright, cheerful surroundings, often in a section of a new building, in which their needs have been carefully considered in the space and equipment provided. This is true in many places instead of in merely a few instances.

Such acknowledgment of the importance of the responsibilities connected with proper maintenance and operation was inevitable when the increasing value of these activities is considered in regard to their effect upon uninterrupted production.

Prove the Value of Your Ideas

OPERATING executives who fail to secure adoption of a cherished plan, are often inclined to blame the management for not taking advantage of a good suggestion. Sometimes the fault lies, to a certain extent, with the executive himself, because he does not put his suggestions in a form that will appeal to the management.

This is well illustrated in one instance where the chief electrician in a factory found, after a careful study, that with a new type of reflector and some adjustments as to spacing and lamp heights he could increase considerably the amount of light on the working area. However, he was much discouraged when his superior merely said, "That's fine; now how many lights can we take out?"

Managers these days are continually looking for methods that effect a saving, in order to meet the stiff competition they must face. This manager, no doubt without thinking, compared light to a machine: if the production of a machine is increased, fewer machines will be required. Probably if he had stopped to think, he would have realized that this reasoning was incorrect, because the analogy does not apply to lighting problems.

Perhaps if this Chief Electrician had approached his superior with a little more explicit information as to what might be expected from the increased light, he would have received his appropriation without further questioning. For example, he could have obtained data on the decrease in the time required to read or set micrometers, to take measurements, or to set up tools. Or, he could have cited the increase in quantity and quality of production that have been obtained in a number of installations which have been described in this and other technical publications.

These and other methods of "selling" the management on better lighting have been used successfully. Practically every plant manager will listen sympathetically to a plan to save money even though it requires expenditure of money to put it into effect. However, the story must be complete and thorough, and have dollar-saving facts behind it.

Check Switch Ratings Carefully for Double-Squirrel-Cage Induction Motors

ALTHOUGH across-the-line motor starting switches of either the hand-operated or the magnetic type operated by a push button are usually shown in catalogs with their ampere and horsepower ratings, it is seldom safe to specify a starting switch by reference to the horsepower rating of the motor only. This is now particularly true when the so-called double-squirrel-cage or other design of self-starting induction motor is being used. The full-load or running current of a standard induction motor of 5-hp. rating, say, operating at 220 volts, 60 cycles, three phase is usually known to be under 15 amp. in most designs, and it has usually been safe to specify a starting switch for such a motor by the horsepower rating.

In the case of a 5-hp. double-squirrel-cage induction motor, however, the full-load or running current at 220 volts, 60 cycles, three phase and 1,200 r.p.m. may be 16 amp. and at 900 r.p.m. 18 amp. or more, and a switch with overload relays capable of handling this service must be used. Again, owing to the use of thermal overload relays in all the various types, except those that are adjustable over fairly wide limits, it is also essential that the exact full-load current rating of the motor be used to obtain the proper setting of the thermal elements for safe overload protection.

Because it is easy to make errors in switch applications when motors and switches are drawn

out of the storeroom stock in a large plant, records are usually kept that give more or less complete information. Such records that apply to the standard, squirrel-cage motor should now be revised so as to make sure that adequate switch capacity is provided for the newer designs of double-squirrel-cage motors that are becoming more and more popular on high-torque starting loads. Failure to do this will certainly damage the switch and perhaps the motor, causing delays that may be expensive but can easily be avoided by a little precaution.

These newer types of motors may come into your plant without your knowledge on such machinery as pumps, air compressors and the like, the motors being furnished by the manufacturer. In such a case the record of the motor characteristics should be obtained before the wiring for the installation is laid out and the starting switches are ordered.

Teach Your Men the Prone Pressure Method

CONSIDERABLE publicity recently attended the efforts by the employees of a public utility company in the Middle West to save the life of a fellow worker who was suffering from a rare form of paralysis that affects the diaphragm and muscles used in breathing. Men working in shifts kept this patient alive for several days by forcing respiration through the rythmic application of pressure, alternating with a momentary relaxation.

Although these efforts were, unfortunately, not successful in restoring the patient to health, they demonstrated in striking fashion the possibilities of artificial respiration.

Enough instances have occurred where after a shock no indication of breathing or heart action could be found, but the life of the person was saved by the use of the prone pressure method of resuscitation, to justify the statement that every man working around electrical equipment should have experience in the use of this method.

One large industrial organization is training several thousands of its men and women employees in the application of this method because it has proved its value not only in cases of electric shock, but also in drowning, asphyxiation, and so on.

In some plants the man in charge of the electrical work considers that it is sufficient for him alone to know what to do in case of accident. Then the question inevitably arises, What would happen if he were the victim of an accident?

A much safer course is to see that every man in the electrical department is thoroughly familiar with the prone pressure method and is kept in practice by frequent demonstrations.

Opinions Are Not the Solution of Power Drive Problems

AN OPERATING executive in an industrial plant recently remarked that some important changes were being held up because he could not decide whether to use group or individual drives for the machines. A question as to the steps he was taking to solve this problem disclosed that he was getting the "opinions" of various men on this subject.

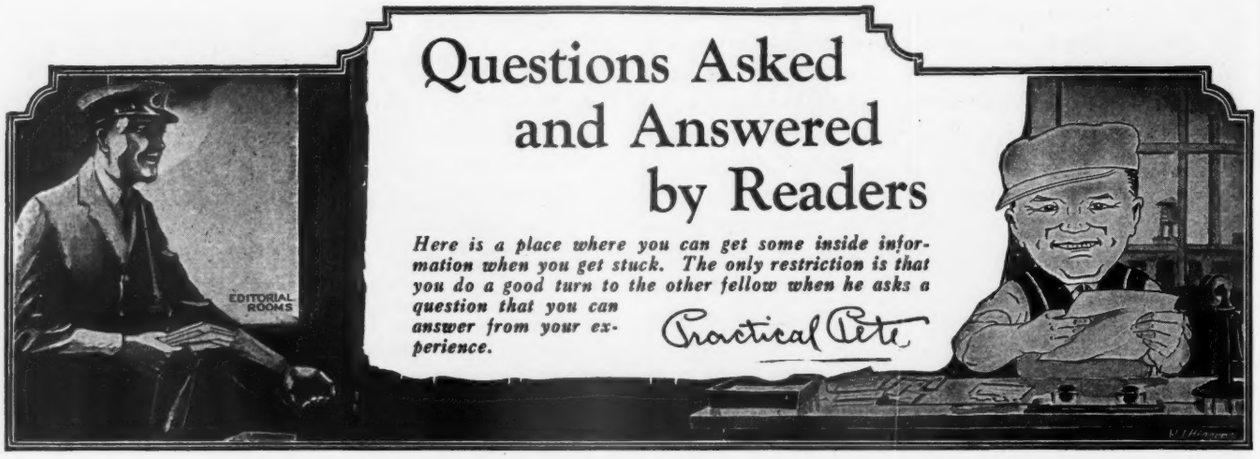
The relative merits of group and individual drives have been discussed at great length during the past few years, and some very important points have been brought out. In actual service both types of drives have proved their worth, when properly applied. Both have their advantages and disadvantages: their defenders and their opponents. Neither is a universal panacea for all operating troubles.

Every operating executive must occasionally decide which type is the better to use under given conditions. This is a very important question. It is by no means something that can, or should be, decided on the basis of prejudice, argument, or hearsay. Stated simply, the problem is to determine how power can under the existing conditions be transmitted in the most economical and satisfactory manner from the motor shaft to the shaft of the driven machine. Fundamentally this is an engineering problem, and it can be solved correctly only by the same procedure that is followed in solving other engineering problems: by proper consideration and analysis of the facts in the case.

The operating requirements of the drive or drives must be clearly defined. Then, assuming that one has a sound, practical knowledge of the possibilities and limitations of the methods and equipment available for power transmission, the selection of the drive is a matter of balancing the investment, operating and maintenance costs, and all other pertinent factors, of one type of drive against the other. An analysis of this character will usually make it possible to select the most suitable drive intelligently and with the minimum of guesswork.

Every installation must in general be given individual study, and any decision should be based on the conditions peculiar to that installation. Therein lies the danger of relying too much on the opinions or experiences of others. Conditions may differ so much that a drive that is well suited to one plant may not be the best or most satisfactory for another plant.

Opinions may be very helpful, but unless they are based on experience with, and apply to, installations that are comparable in all important respects, it is much safer to check them against an analysis based on known facts.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

QUESTIONS

Who Can Answer These?

Trouble in Setting Circuit Breakers

We have had difficulty in accurately setting our three-phase, 550-volt oil circuit breakers, which range from 80- to 400-amp. rating. I shall appreciate it if readers will tell me the best method of making this adjustment, by the use of a phanton load. Can a water rheostat be used as the load, or is some other device more suitable?
Vancouver, B. C., Can. A. M. S.

Changing Single-phase Motor for Three-phase Operation

I have a 2-hp. single-phase, 110/220-volt, 1,725-r.p.m., 60-cycle, repulsion-reduction motor that I wish to operate on a three-phase supply. I do not want to rewind the rotor if I can help it, but should like, if possible, to increase the horsepower rating, keeping the speed the same as before. The motor drives a lineshaft from which we operate a small lathe, a drill press and an emery wheel. What will I have to do to this rotor to change it for three-phase operation? When the motor is operated three-phase, will the starting torque be greater or less than it was on single-phase operation?
Farmland, Ind. A. G. B.

Polarity of Interpoles

I do not thoroughly understand the rule governing the polarity of interpoles and wish someone would explain how it works out under different conditions. For example, on machines that have two interpoles, I have often found them to be of opposite polarity. Was this polarity correct? Can one rule be made to apply to a motor having any given number of main poles and interpoles? I shall be grateful for your help on this question.
Mohiland, Utah. K. W. F.

Cost of Interior Painting in Mill-Type Building

Our main building has not been painted on the inside for several years and needs it badly. It is a four-story mill-type building with sawtooth roof. The area of each floor is about 25,000 sq.ft. The ceiling and upper part of the walls are to be painted mill white and the lower part of the wall a dark brown I should like to get the experience of other readers on the use of air paint guns on such construction, and what they think such painting should cost per sq.ft. Also, what should brush painting cost? Any information you can give me will be appreciated.
Springfield, Mass. B. W.

Oil Grooves in Bronze and Babbitt Bearings

We rebuild our bearings and I wish that readers would tell me the best form of grooves to cut in oil-lubricated bronze and babbitt bearings up to 3-in. bore, for shaft speeds of about 300 to 1,800 r.p.m. I should like to know how grooves should be cut in both solid and split bearings. When should straight and when should criss-cross grooves be used? How wide and how deep should grooves be cut? How should grooves be cut for grease lubrication?
Scranton, Pa. B. V. W.

Eliminating Radio Interference from D. C. Generator

Interference with radio reception in our community has been traced to one of our 100-kw., 230-volt, 275-r.p.m., Type N, engine-driven Westinghouse generators. We ground the commutator and adjusted the brushes and holders so that there is no sparking, but the only way that the trouble can be stopped is by pulling the main switch, or by reducing the voltage from 230 to 160. When the voltage is raised, the trouble returns. The radio interfence seems to be greatest at one end of the engine stroke; in town it is possible to count the revolutions of the engine on a radio set. I believe that the engine speeds up at the end of one stroke, thereby increasing the generator voltage. If condensers are a practical remedy for the trouble, what size should they be? How should they be connected to the generator? What other method could be used to rectify the trouble? We are very anxious to get this situation cleared up and I shall appreciate any help you can give me.
Vandergrift, Pa. G. J. K.

ANSWERS

Received to Questions Asked

Checking the Alignment of Lineshafts

I have always heard that in checking the alignment of a shaft, the belts should be thrown off. It seems to me that the belts should be left on the pulleys to give the approximate operating conditions. In other words, a belt may draw a pulley and shaft and its bearing to one side in operation, but if the belt is off, the shaft may appear to be in line. I believe that the alignment should be checked as nearly as possible under operating conditions. I wish some of our readers would discuss this question.
Moline, Ill. H. J. K.

IN REPLY to H. J. K., shafts could be aligned with the belts on the pulleys, but it would be almost as much of a running approximation as it is to align without the belts on. The moment the machinery is put to work various changes and deflections take place which destroy the alignment made when the shaft is idle, with belts either on or off. Machines starting and stopping, running idle or on peak loads, bends that may exist in the shaft itself, moving loads on the floor or other floors—these are some of the things that would affect the alignment previously made.

If a shaft were aligned for certain belts on at any one time it would have to be re-aligned if other belts and pulleys were put on. Belts that have been running somewhat loose may be taken up and, if the shop men prefer belts snapping tight, the replaced belt will draw the shaft to one side until the leather stretches again.

This assumes the use of shafting of ordinary sizes. It would be possible to install large shafts that would be so stiff that they would not be susceptible to belt pull to any appreciable extent, but that would be poor engineering and expensive for all time.

Self-aligning bearings in the hangers do away with the dire effects of the shaft springing under loads. Except where an extremely light shaft has been put in by uninformed persons or where the load carried has been multiplied, there is very little trouble from belts pulling it out of alignment, because of the elasticity of the shaft and the self-aligning feature of the bearings. The need for this was early recognized and fixed bearings were changed to swiveling bearings.

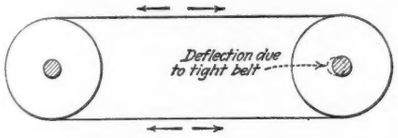
Shafts are seldom so straight that a line 100 ft. long does not show an

eccentricity at some point. The weight of the steel itself causes a certain deflection. A 3 7/16-in. shaft with hangers spaced 8 ft. apart will sag nearly 3/32 in. from its own weight, if measured half way between the hangers.

Probably the greatest stress put on a shaft is when a big belt is snapped in place. This may be indicated by the accompanying diagram. It is not at all uncommon for a belt to be broken apart, either in the leather or at the joint, when it is forced on when too tight.

Assume for illustrative purposes that the shafts cannot turn and that the grip of leather upon metal is such that each half of the belt becomes a rod in tension; then the stresses in the belt are as indicated by the arrows in the diagram and the shaft will be deflected as shown. Assume further that this is an 8-in. belt midway between hangers on 8-ft. centers and the shaft is 3 7/16 in. Roughly, belting breaks at 3,000 lb. pull per sq.in. of section.

This 8-in. belt therefore presents $8 \times \frac{1}{4} \times 2$, or 4 sq.in. of leather for the load, if the thickness is $\frac{1}{4}$ in. At



This shows the conditions produced by putting on a belt that is too tight.

half the breaking strength, this represents a pull of $1{,}500 \times 4 = 6{,}000$ lb. A load of 6,000 lb. on this shaft is the same as that of a beam resting on supports at the end, because of the swiveling of the bearings. This creates a deflection of 0.527 in. at the center. This is an extreme case, theoretical only, but it does not show a startling deflection for a slow-speed shaft, and many things would lessen this spring in practice; for instance, there would not be that amount of pull between two shafts with that size of belt properly installed, and, if the length were coupled up in a line, the adjoining sections would exert some straightening or stiffening influence.

Inasmuch as we cannot align shafts while the loads are on them, we obtain the best approximation by doing it with a stripped shaft. If the shaft and hangers are selected of a size in accordance with good practice, there will be no serious trouble unless conditions are much out of the ordinary.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.
Middletown, N. Y.

Connection for Ammeter and Relays

I should like to know what connection to use on a circuit containing an ammeter, two current transformers, two trip coils for an oil circuit breaker, and some kind of switch that will permit switching the ammeter so as to read the current in each phase of a three-phase circuit. Can I read the current flowing in the third phase when using only two current transformers?
Chicago, Ill. A. W.

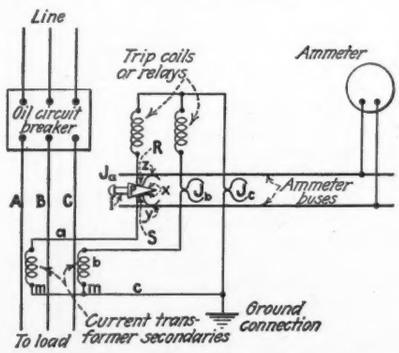
REFERRING to the question asked by A.W., it is assumed that by "relays" he means the trip coils of the circuit breaker. The desired result may be obtained if the connections are made as shown in the accompanying diagram. The details are shown more or less conventionally since there are available, through switchboard manufacturers, standard ammeter switches which accomplish the result indicated in a simple manner with a minimum number of connections. The questioner is referred particularly to the catalogs and publications of the Westinghouse Electric & Mfg. Co. and the General Electric Co. for more detailed information. The accompanying diagram is simple, but a few words of explanation may not be out of place.

Current transformers are inserted in lines *A* and *C*, care being taken to note the polarity marks so that both are at the same end as *M*. The secondary leads are connected two in common at the same end, and the other two leads *a* and *b* are carried to the trip coils by way of the ammeter jacks *J*. The common secondary lead *c* is carried to the common trip coil lead forming the return circuit *c* through a third ammeter jack. The jacks, J_a, J_b and J_c are shown conventionally, as they are similar to ordinary telephone jacks, so that the method may be more easily understood.

Plug *P* has a metal point and insulated sections at *x*; should it be desired to read the current in line *A*, the plug is inserted in the receptacle for jack J_a; the jack is so tapered that contact is made at *y* and *z* with the ammeter buses before the insulated section of the plug separates the sections *R* and *S* of the jack and when the plug is further inserted *R* and *S* separate, allowing the current to flow through the ammeter, as indicated by the arrows.

The currents in lines *B* and *C* may be read by inserting the plug successively in jacks J_b and J_c. The arrangement indicated in the diagram is similar to the method used on arc circuit boards.

As previously stated, the jacks have been illustrated to show the principle involved; as a rule some form of switch is used on most switchboards by means

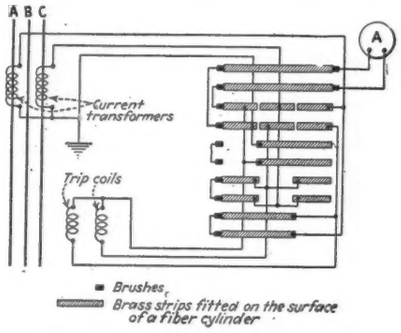


This connection scheme shows how one ammeter may be used to indicate the current flowing in phases *A*, *B* or *C*.

of which the different currents may be read by turning a single handle to any one of three positions. The common lead *c* should always be positively and securely grounded. As a further precaution, the contacts *R* and *S* should be carefully tested to avoid any possibility of opening the secondary with full-load current flowing in *A*, *B* or *C*, for such a condition would give rise to dangerous operating conditions.

C. O. VON DANNENBERG.
Electrical Division,
General Engineering & Management Corp.,
New York, N. Y.

IN REGARD to the question asked by A.W., one ammeter can be arranged to indicate the current flowing in the different phases of a three-phase circuit. Although only two transformers are used, it is possible to obtain a reading of the current in the third phase, for in a three-phase system the current flowing at any instant in any one of the three phases is equal to the vector sum of the current flowing at any instant in the other two phases. For instance, the current in phase B is



Method of connecting one ammeter to a three-phase circuit through a three - way secondary transfer switch, to permit measuring the current in any one of the three phases.

equal to the vector sum of the current flowing in phases A and C.

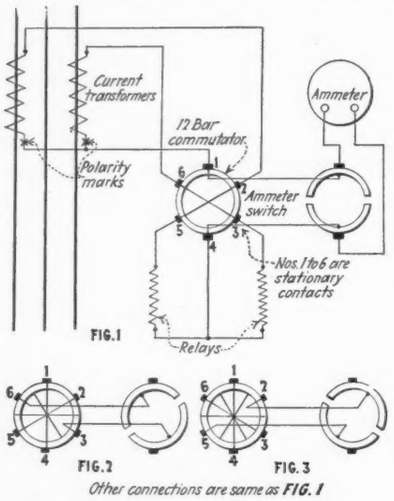
The illustration shows the method of connecting one ammeter to a three-phase circuit, using two current transformers, so that the ammeter can be readily switched to indicate the load on the desired phase. In order to do this, it is connected to a three-way secondary ammeter transfer switch which is in turn connected to the two trip coils and the two current transformers.
Chicago, Ill. A. NOEPPEL.

IN ANSWER to A. W.'s question, the connections of an ammeter switch to two current transformers and an ammeter are shown in the accompanying diagram. The trip coils of the oil-switch are sometimes connected through relays or connected as straight series trip coils. In the latter case, the trip coils, if designed for 5 amp., would be placed in circuit where the relay coils are shown.

The ammeter switch resembles the commutator and brush rigging of a generator, on a small scale. The commutator has 12 segments all of which except two are cross-connected: these

two are extended to a two-segment commutator. The 12 segments operate under six stationary contacts that are connected to the transformers and relays as shown in the diagram, and the two-segment commutator operates under two other stationary contacts that are connected to the ammeter.

The commutator can be rotated only through a small arc, and in this distance there are three positions each of which places the ammeter in each of the three different phases. Fig. 1 shows the switch set in its centre position in which the ammeter is connected in circuit with the common wire from the two current transformers, and will thus indicate the current flowing in the middle wire of the three-phase system. If the switch is turned to the



This ammeter-transfer switch will connect the ammeter to any one of the three phases.

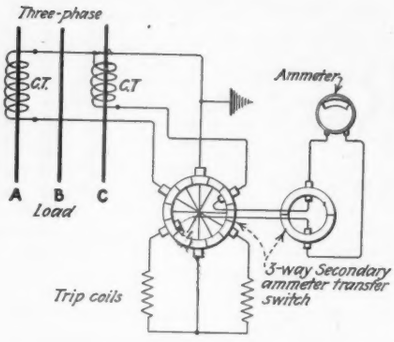
Fig. 1 shows the switch position for obtaining a reading in phase B. The ammeter can also be connected to either of the other two phases, as shown in Figs. 2 and 3.

left or right of the centre position, the ammeter will accordingly be connected in circuit with one of the two current transformers, as indicated by Figs. 2 or 3, thus indicating the current in each of the other wires.

As the switch is rotated, provision is made for short-circuiting the transformers while passing from one position to the next.

ERNEST DICKINSON.
Kimberley, B. C. Can.

THE question asked by A.W. need cause him no worry, as it is entirely feasible to use two current transformers in a three-phase circuit to obtain ammeter readings in all three phases. He will need a special ammeter transfer switch such as a Westinghouse Type R. S. Style No. 279,056 or a General Electric Catalog No. 2,192,182-G1. With either of these switches the ammeter can be cut into any phase without opening the secondary circuit from the current transformers. The trip coils to operate the oil circuit breaker can be operated from the secondary circuits of the same current transformers. The accompanying diagram



Method of connecting one ammeter to a three-phase circuit so as to indicate the current in phase A, B or C.

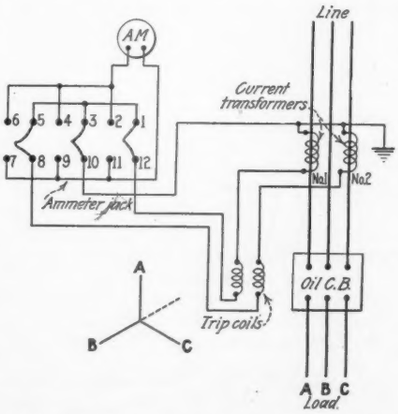
shows the manner of connecting a G.E. ammeter transfer switch so as to obtain ammeter readings in any phase, at will, by merely turning the handle of the transfer switch.

Electrician, CHAS. A. PETERSON.
Fairbanks Exploration Co.,
Fairbanks, Alaska.

ANSWERING A. W.'s inquiry, the current in the third phase leg can be read when two current transformers are used, with the connections shown in the accompanying diagram. It is easy to see how the current may be read in phases A and C, as current transformers are connected in these. The principle of reading the current in phase B can be shown by a simple vector diagram wherein the two outside current readings are 120 electrical degrees apart; therefore, the current in phase B would be the resultant.

To make use of the accompanying diagram, I recommend that A. W. first purchase a factory-built, ammeter jack. There are a number of these on the market, made by the leading electrical manufacturers. As there is an element of danger in handling current transformers, I would not recommend the use of a home-made device, unless the user has excellent facilities for building such apparatus.

Referring to the diagram, the method of using the jack is as follows: To

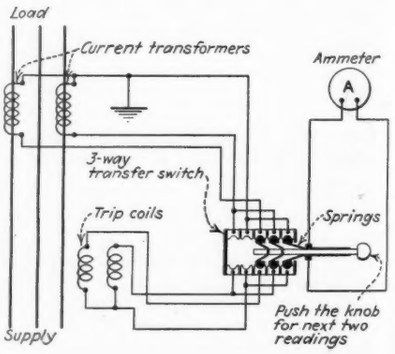


This shows the connections of an ammeter jack for plugging one ammeter into any phase of a three-phase circuit.

obtain a current reading in phase A, insert the plug in the hole containing contacts *1*, *2*, *11* and *12*. As the plug is pushed in, it connects points *1* and *2*, also *11* and *12* before opening spring clip *1-12*, thereby connecting the ammeter in circuit with the No. 1 current transformer.

To obtain current readings in phases B and C, insert the plug in the hole containing contacts *3*, *4*, *9* and *10* for a reading in phase B, and in the hole containing contacts *5*, *6*, *7* and *8* for reading in phase C. With this method of switching the ammeter, the current transformers are short-circuited at all times when the ammeter is not connected for a reading in one of the phases. G. H. WINTERSTEEN.
Cleveland, Ohio.

IN REPLY to A.W.'s question, the accompanying illustration shows the connections which will allow one ammeter to be successively connected to each phase of a three-phase circuit. This method of switching the connections so that the ammeter will indicate the current flow in each phase is practically the same as that used when employing



This shows how one ammeter may be used to indicate the current in each phase of a three-phase circuit.

a three-way ammeter transfer switch. The accompanying diagram indicates the connections which will enable A. W. to secure a reading on the ammeter from any of the three phases, without cutting open the current transformer secondaries, or interfering with the operation of the trip coil.

The General Electric Co. and the Westinghouse Electric Co. can supply the desired transfer switch, and a diagram of the connections necessary. I would advise A. W. to get in touch with a representative of either of these companies in his locality for further information. E. J. ELVISH.
Fort William, Ont., Can.

Using Large Diameter Pulley on Motor

It is practicable to use a 20-in. pulley on a 25-hp., 750-r.p.m. motor? This would result in a peripheral speed of the pulley of 3,926 ft. per min. Would this be good practice? What objections would there be to using this size of pulley on the above motor in view of

the fact that the motor manufacturer does not recommend a pulley of this diameter? Can some reader tell me what types of pulleys I could use or could not use in this case?
Toledo, Ohio. F. H.

THE size of F.H.'s motor pulley is limited by the mechanical clearance and the peripheral speed. The most economical belt speed is from 4,000 to 4,500 f.p.m. and since the speed is 3,926 f.p.m. it is within the range of practical speeds for oak-tanned or chrome leather belting.

For pulleys 12 in. in diameter and over, double belts are desirable because they will be narrower than a single belt for transmitting the same horsepower and would, therefore, reduce the overhang on the motor shaft. Motor manufacturers usually specify the minimum pulley diameter to be used and the maximum allowable width of the belt (or pulley face) to insure that the pressure on the bearings will be within the limits of their design.

When pulleys of large diameter are used they should be as light as possible to reduce the pressure on the bearings. Composition paper pulleys and pressed-steel motor pulleys are satisfactory. Flat-face, crowned, and double-flanged pulleys are used, depending upon the nature of the load and kind of service. Where the belt is shifted from loose to tight pulleys the face of the pulley should be straight. Where the motor is started under load, or heavy loads are imposed at intervals, crowned or double-flanged pulleys are used.

E. H. LAABS.

Engineering Department,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

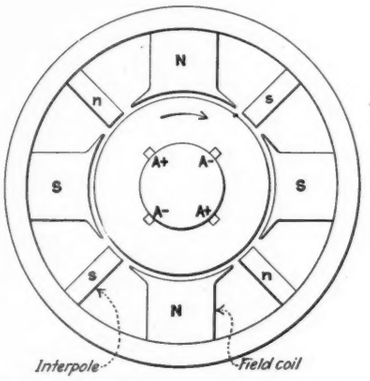
What Is Wrong With This Exciter?

We have a 7½-kw., 125-volt, 60-amp., 1,200-r.p.m. exciter that has always given us considerable trouble. It sparks badly, thereby shortening the life of the brushes and of the commutator. Flats appear on opposite sides of the commutator and the individual bars are badly burned. Channels are burned lengthwise in the center of the bars to a depth of about $\frac{1}{16}$ in. This machine has four-poles, the commutator having 49 bars on the original armature, while the spare armature has 97 bars and 49 coils. Each time we turn the commutator we undercut the mica and test the armature on a transformer or growler. When an armature is replaced in the machine we fit a new set of brushes as supplied by the maker of the machine, and start it with a normal load of 45 amp. It will run well for a day or two with scarcely any sparking. Then it begins to spark and the commutator blackens and heats up. I wish other readers who have had similar experience would tell me how they corrected the trouble.
New Philadelphia, Ohio. R. F. P.

THE trouble encountered by R.F.P. is probably due to one of the following causes. In the first place, the speed of the machine, which is 1,200 r.p.m., is fairly high for a d.c. machine, although there are d.c. machines running at 3,600 r.p.m. and giving good service, but most of these have one or more rings shrunk around the commutator bars. These rings are put on to prevent centrifugal force from throwing the bars out of alignment.

A commutator that is to run at a high speed must receive exceptional care in its assembly. A green commutator must be carefully tightened, baked at the proper temperature, allowed to cool and then tightened up again. After the commutator is assembled and the armature wound, the commutator should be tightened once more, and when the completed armature is removed from the baking oven it is advisable to tighten the commutator studs. The heating and centrifugal force during operation in actual service will sometimes cause the bars to rise unevenly, and sparking will result. The remedy for this trouble is to tighten the studs while the machine is hot, and then turn the commutator.

The interpoles of the machine, if it is so equipped, may be bucking the field proper; that is, connected for the wrong direction of rotation. The proper location of the N and S interpoles, with respect to the N and S poles of the field, for a given rotation, is shown in the accompanying illustration.



This shows the proper polarity of interpoles with respect to field poles for clockwise rotation of armature.

Then again, the polepieces may be too far from, or too close to, the armature, provided there are shims placed under the interpoles. The evidence seems to point to either a defective field structure or to the fact that the machine was originally improperly designed. By consulting the manufacturer, some reliable information can probably be obtained.

Again the bearings may be worn too much, the brushes may not be exactly in the neutral plane or the machine may be vibrating too much. When the machine was new, was the mica undercut in the commutator? All commutators are not milled when new, although most high-speed commutators are milled.

Be sure that no oil reaches the commutator, and that the brush tension is not too heavy; about 1¾ lb. should be right. I believe that The National Carbon Co.'s brush No. 255 would be a good brush for this machine.

In turning the commutator, a speed of about 500 ft. per min. is generally satisfactory. The cut should not be too deep because if the cut is deep the tool has a tendency to twist the segments and thereby cut deeper at one edge than at the other, making a great deal of difference on a high-speed machine. The ideal method of truing up a commutator is to grind with a soft-faced revolving stone while the commutator is running at its operating speed. This method will remove any irregularities which the high speed might cause.

The brushes may span too may bars, or the brushes may not be spaced properly. To check the location of the brushes procure a piece of thin paper and pull it tightly around the commutator, marking the lap. Remove the paper and lay off as many divisions as there are brush studs. Replace the paper on the commutator and set the toes of the brushes at these lines. If the brush studs are not parallel to the commutator, bend them until they are. On the other hand, the brush pressure may be too low. If the machine is operated in parallel with other machines, cross-currents may be causing the arcing. If the field poles are unequally spaced around the frame, this is due to faulty manufacture.

GRADY H. EMERSON.

Birmingham, Ala.

IT MIGHT we well for R.F.P. to examine the armature for loose leads or for broken connections at both points of the commutator where the burning is in evidence. A break or open circuit in the coil connected to the burned bars is very probable. Since the exciter has four poles, and is of the series-wound type, it may be that the circuit is open on only one side. Under certain conditions a ground or a flying ground might be the cause of the trouble mentioned.

A test with a growler will be of no use in R. F. P.'s case, but a bar-to-bar or drop test with a sensitive milliammeter may prove helpful.

Ft. Dodge, Iowa. CLAUDE D. MARTIN.

ANSWERING R.F.P., this question presents a peculiar problem, for the trouble does not appear to be in the armatures, although it may seem to be there.

It might be well to check up for the usual armature troubles, particularly brush setting and cleanliness. Since the trouble is manifesting itself in two armatures, it is more than likely to be found in the field winding.

Trouble in the field could be caused by a poor air gap, or a short-circuit in a field coil; or there is a possibility that the frame has blow holes in it, thereby causing a peculiar relationship in the reluctance of the frame.

The air gap can be easily checked and corrected by the use of shims, while a possible short-circuit in the shunt field coils can be checked by impressing a constant voltage on the coils in series, and then measuring the drop, across each.

Blow holes in the frame can be checked by using an X-ray apparatus. The bearings may be causing air-gap trouble, moving up and down due to the weight of the armature; also, a side-wise motion may be caused by the use of a belt drive.

Trouble caused by two bars burning in the commutator is usually associated with armatures that are series wound, in which case the burned spots are oppo-

site and their number is half that of the number of poles in a machine. It would be unusual, however, for both armatures to be open-circuited.

Inequality of brush tension, poor brush spacing, high bars, and a wrong type of brush are often sources of trouble in commutators.

I would, first of all, blame this commutator trouble on the field; therefore, it might be best to work back from the field, and in addition to the possible troubles already mentioned it might pay R. F. P. to look into the design of the exciter in order to note whether the field is weak or enough iron has been used. E. J. MORRISSEY.

Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

REFERRING to R. F. P.'s question, I would surmise from the information given that there is an open circuit in the armature. It is very likely that the coil connections are poorly soldered to the bars where the burning occurs. If this trouble has been going on for some time, the insulation will be burned back on the coil leads, necessitating renewal. When the leads are resoldered it will be necessary to raise them from the slots and scrape them very carefully. Also, clean the slots in the commutator bars, as they will be badly corroded by the excessive heating. GORDON S. MAYHEW.

East Angus, Que., Can.

THE question asked by R.F.P. is hard to answer offhand, owing to the many factors that would bring about the condition he describes.

The question fails to state how the generator is driven: that is, belted or direct. Sometimes a belted machine will spark due to improper belt lacing in which case an endless belt is best. In a direct-connected machine worn or loose bearings may cause the trouble, and the other causes which should be investigated are brush pressure, brush spacing, air gap, defective fields, brushes off neutral, brushes not of proper thickness, and wrong grade of brushes. A low brush pressure will cause a poor contact between the brush and the commutator, the result being that the current must travel through a small arc which burns both brush and commutator, causing high mica, and the heat of the arc causes the commutator to heat. If the brush pressures are unequal, the brushes with the most pressure on them will carry the most current. Sparking will result when the brushes are not properly spaced, when the brush studs are not parallel with the commutator bars, and when the brushes span too many bars.

I would also suggest that R. F. P. measure the drop across the field coils. It should be the same for each field, and, if not, the coil having the highest drop is defective.

To check the brush spacing, obtain a piece of wrapping paper that will reach completely around the commutator. Divide the paper into four equal parts, for a four-pole machine, place it around the commutator with the toes of the four sets of brushes at the divisions in the paper. If each set of brushes does not touch the corresponding line, it should be adjusted until it does so.

If the sparking does not stop when the brushes are shifted forward or backward, the fields and air gaps should be examined.

To test for brush thickness, use a low-reading voltmeter, and two ordinary lead pencils, trimming them down flat on one side but do not expose the lead. At the top of the pencils cut a groove down to the lead, attaching a piece of lamp cord to each pencil. Next remove a brush and hold the flat sides of the pencils against the front and back side of the brush-holder, with the leads touching the commutator, and read the voltage. This reading will give the commutation voltage. Shift the brushes until they do not spark. Again read the commutation voltage; if it has decreased, the period of commutation is too short and the brushes are too narrow. If the commutation voltage has increased, the brushes are too wide spanning too many bars, or the neutral field is too small. If making the brushes narrower does not stop the sparking, it may be necessary to widen the neutral field by increasing the distance between adjacent pole tips.

Should the air gaps be unequal, shim up under the poles having the largest gap, or grind off some of the poles having the smallest gap, for in lap- or parallel-wound machines an unequal air gap will cause trouble.

Flat spots may also be caused by a loose commutator, surges of load due to short-circuits, or an unbalanced armature. In that case the armature may be balanced by adding weight to the light side.

I sincerely hope that some of the points herein mentioned will help R. F. P. to solve his problem.

Indianapolis, Ind. M. V. MILLER.

Cause of Fuses Blowing on Transformers

During a recent violent lightning storm, the fuses were blown on one of our 10-kva., 2,300/220-volt, single-phase transformers. This transformer supplies a small, lighting distribution system. The transformer is protected by a pole-type lightning arrester. After the storm was over the fuses were replaced and the transformer operated satisfactorily. I shall appreciate any information that readers can give me on what caused these fuses to blow. I will be very much indebted to any reader who will advise me on this subject.

Wichita, Kan. Z. F. D.

IN ANSWER to the question asked by Z. F. D. we may first consider a transformer fuse as an element designed to melt at a predetermined current value, and intended to act as a protection against abnormal conditions of current. Fuses are generally constructed so that they will carry continuously 110 per cent of their rated current.

A lightning arrester is ordinarily arranged to immediately relieve the system of excess energy due to rises in potential. To do this successfully a path to ground must be provided, the resistance of which decreases as the amount of energy to be discharged increases; that is, as the rise of potential increases. When the surplus energy has been discharged, the resistance of the path to ground must return to its original value immediately; otherwise the effect on the line will be practically a short-circuit, tripping circuit breakers, shutting down the system and thereby defeating the real purpose of the lightning arresters. From the above it is evident that fuses are intended to protect the transformers from abnormal currents and the lightning arresters are intended to protect the transformers from abnormal voltages.

A properly designed transformer, well built of the best materials, will survive a considerable surge of voltage. This surge may not be great enough to cause the lightning arrester to function, but might cause a sufficient increase in current to blow the fuses and yet not damage the transformer windings. The operating records of any light and power company will show that it is not uncommon for lightning storms to cause fuse protecting transformers to blow.

East Kingston, N. H. H. S. RAMSAY.

THE cause of the fuses blowing on Z.F.D.'s transformers may have been due to the line being struck by lightning, a high-voltage wave being induced in the line by induction from an overhead cloud, or by a lightning discharge in the vicinity. It is not likely that the lightning struck the line, but one of the other two conditions may have caused the fuses to blow. Lightning arresters are more protection against a direct stroke of lightning than against an abnormal rise in voltage, or when the rise in line voltage is simply caused by induction, the voltage may not be high enough for the lightning arresters to act, but high enough to blow the fuses. When fuses have been in use for a considerable length of time, their current-carrying capacity is gradually reduced, possibly by corrosion. Fuses are likely to blow, even though the arresters function properly. But, if the arresters do not function properly, fuses would probably not blow quickly enough to protect the line. In Z.F.D.'s case, undoubtedly a high-voltage line current was induced in the line during a thunder shower, the voltage being high enough to cause the line current to blow the fuse but not large enough to do other damage. W. E. WARNER.

Shefford, Bedfordshire, England.

IN ANSWER to Z.F.D.'s question the writer has based his reply wholly on 20 years of experience, in repairing apparatus which lightning had damaged.

Lightning rarely acts twice alike and the troubles that it causes to electrical appartus can be divided into two classes.

The first class represents those troubles caused by lightning striking the primary line feeding the transformers. This is usually disastrous to apparatus that is in the path of the lightning. A lightning arrester may take care of this discharge, and it may not, for the perfect lightning arrester

is yet to be devised. I advocate the use of lightning arresters, but do not expect 100 per cent protection from them for oftentimes damage to transformers is done before the lightning reaches the arrester. There are few pieces of electrical apparatus that receive so little attention as a lightning arrester. Consequently, this neglect frequently is responsible for the arrester not functioning properly on a moderate charge.

The second class of troubles due to lightning are less serious. Even if the transformer is properly fused for carrying its rated load, a small surge caused by lightning, in addition to the normal load on the fuse will cause it to blow, thereby probably saving the transformer serious damage.

It is a natural characteristic of lightning to want to reach the ground, but as air is a good non-conductor, it is only natural to expect that a stroke of lightning coming within striking distance of a nearly perfect conductor to ground, will divert its course to a conductor of less resistance. Before the charge leaves the transformer or conductor on its way to the ground, it has a habit of leaving trouble in its wake.

Lewiston, Maine. A. C. BARKER.

Use of Time Switches

Many times I have felt that clock-operated time switches could be used to advantage in my plant, for instance on baking ovens and yard lights. Before installing these devices, however, I should like to obtain the viewpoint and experience of readers as to where these switches can be used to advantage around the industrial plant. Where are readers now using these switches to advantage and, also, where do they think they could use them if they were to install them at every point at which they would be of value?

Pittsburgh, Pa. K. E.

REGARDING the question by K. E., my experience with time switches has been that they will usually soon repay their initial cost.

When it is necessary to control yard lights that need to be switched on and off at inconvenient times, it is advisable to use time switches, for without them lamps that burn at night are frequently switched on and off at the watchman's convenience.

In the case of electric furnaces, muffles, ovens and the like it often pays to use time switches so as to avoid keeping a man on duty for the specific purpose of switching the current on or off at a certain time.

To obtain satisfactory results, with this type of control device, it is advisable to purchase high-grade switches and then put them under the care of one man who should be held responsible for their proper operation. When the clocks are wound at regular intervals, I have found time switches to be absolutely reliable. W. E. WARNER.

Shefford, Bedfordshire, England.

THE question asked by K. E. should be of especial interest to all large plants, as some of the practical uses of time switches are: controlling industrial process machinery and equipment for pre-determined periods; control of yard, shop, and display lighting; pre-determined control of night and special lighting required by watchman; and automatic control of special alarm systems.

I would suggest that, first of all, K. E. make a careful survey of conditions at his plant to determine whether he wants a definite control over his baking ovens and yard lights, or prefers to maintain manual control in some parts of his plant system. In deciding this point he should balance the cost and convenience of time switches against the cost and convenience, or inconvenience, of the present manual control.

There are many uses for time switches, which make for accurate control, so far as time is concerned, of any equipment to which they can properly be applied.

NATHANIEL W. BLANCHARD.

Inwood, L. I.

IN REPLY to K. E.'s inquiry we have found clock-operated time switches to be most useful time- and money-saving devices, for they can be used to advantage in almost any installation where the time of opening and closing circuits is essential either from the standpoint of economy, or quality of the product being manufactured.

One point I wish to bring out from my experience with time switches is that care is necessary in the selection of a suitable make of switch, which should be made standard throughout the plant. Besides several American-made switches that are very reliable, there is a time switch of a foreign make that is a very fine piece of apparatus, but it is a bit too delicate for the rough service and neglect that a time switch is frequently subjected to. The clock part of these switches is difficult for the average American jeweler or watchmaker to repair.

Time switches of both American and foreign makes are available in practically any voltage.

G. H. WINTERSTEEN.

Cleveland, O.

Power Factor of Transformers Feeding a Resistance Load

We have two 700-kva. single-phase, 25-cycle, 11,000/220-volt Allis Chalmers transformers with an impedance of 58 per cent that are to be connected in open delta to feed a 400-kva. annealing oven which is heated by resistors. All the impedance in each transformer will be removed down to 12 per cent, which is the limit. Will some reader please tell me what the efficiency and power factor of the transformers will be when they are operated in this manner.

Keokuk, Ia. L. M. S.

IN ANSWER to L. M. S.'s question, in order to calculate the efficiency in this case, it would be necessary to know the iron loss and copper loss in these particular transformers. This information can be obtained by test, but could be more easily obtained by consulting the manufacturer who, without question, has these data on record. The full nameplate data, including the serial number, should be sent to the manufacturer. If this information is obtained, the efficiency can be computed as follows: Let W = load, and w = copper loss plus core loss. Then, 100 W $\div$ (W + w) = efficiency.

The efficiency in this case, however, will not be so high as might be desired, due to the fact that the transformers are much larger than required which will increase the iron and copper losses, and that they are connected in open delta. The open delta connection will reduce the capacity of the bank about 9 per cent. The type of load that is to be imposed on these transformers is in the inquirer's favor, as there will be practically no regulation or power factor difficulties caused by this load.

GUY H. WINTERSTEEN.

Cleveland, Ohio.

Repairing Roof Tank

We have a yellow pine roof tank used for storing warm water at our plant. This tank is about 15 ft. in diameter and 45 ft. high. It is made of vertical staves which are held in place by means of circular steel bands, much as is the case with railroad water tanks. Four of these staves were apparently not all hard wood and have rotted away so that they are half gone in places, the remainder of them apparently being hard wood, are sound. The tank cannot conveniently be spared long enough to dismantle and put in new staves; so we would like to know what is the best method of repairing it. The rotting of the wood is on the outside only. We have thought of scraping out all of the rotten wood carefully and then filling in the space with a thick cement grout such as is used in fixing up trees where branches have broken away or decay has taken place. I should like to obtain the advice of readers on the merits of this method and also their suggestion on other methods of making this repair.

New Haven, Conn. H. W. F.

THE repair work involved in the question asked by H. W. F. must be done on the outside of the tank.

I would suggest that H. W. F. carefully scrape out the rotted wood and make a clean surface. Then paint the scraped surface with black asphaltum paint, after which a mixture of tar and portland cement can be used as a filler. When preparing the filler, the tar should be heated and the cement thoroughly mixed with it in a 50-50 proportion. As this mixture hardens quickly, it must be applied without delay.

As soon as the mixture is applied to the recesses and packed in solidly, an iron or wood covering, properly shaped, should be bound over the mixture to make certain that it adheres to the asphaltum binder. After the mixture has set, this covering or support may be removed if desired.

I know from experience that this tar and cement mixture will adhere to wooden side walls and roofs, keeping moisture out, and as the cost of such a job should be small, I can see no reason why it would not solve H. W. F.'s problem.

In the event that this method is used, I should like to hear from H. W. F. concerning the success of the repair job.

NATHANIEL W. BLANCHARD.

Inwood, L. I.

Correction

IN THE answer given by Claude D. Martin to W.T.'s question, on page 138 of the March issue, an error was made in the third line from the end of the first paragraph. This line reads "amperage is determined by dividing," whereas it should have read, "amperage is determined by *multiplying*."

Electrical Service

AROUND THE WORKS

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Illuminating Dark Spots by Special Fixture Units

WHEN properly placed, small lighting units are often economical and efficient, even though the tendency of modern industrial lighting is toward large units which are usually located some distance from the working plane. In general, large lighting units are highly satisfactory, but one does find an occasional machine, or a cramped corner which, to be properly lighted, requires some special form of fixture.

There are on the market a number of excellent adjustable fixtures. Some of these fit the requirements of certain machines; some are so built that they are applicable in the strangest of positions. If one of these patented fixtures meets the conditions of the problem in hand, then it is easily solved. However, there are two prominent objections to such fixtures: First, the expense of outfitting a large number of similar machines may prove to be so large that the cost will prohibit their installation. On the other hand, the number of flexible joints may make the fixture so bulky as to be objectionable.

It requires only a little thought and very little labor to build fittings that will fit the job, and once in place, the economy of current consumption and the increased efficiency of the operator will usually more than compensate for the small expense of construction.

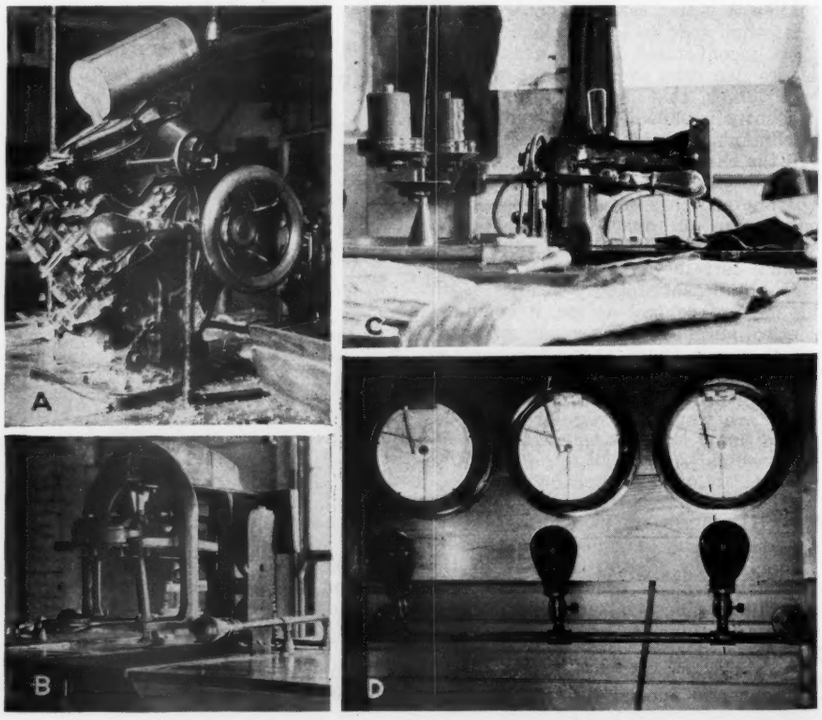
The accompanying illustration is typical of what can be inexpensively accomplished with small lighting units. For example, with the eyeletting machine, shown at *A*, it was found necessary to throw the light on the platen from the right side, and to protect the operator's eyes from the glare of the light.

The sole-cutting machine shown at *B*, is a particularly good instance of the need for special lighting. The stock to be cut passes over the platen, the pattern being held by the cast arms just above the platen. In order that the operator may watch the course of the knife, light must be thrown between the platen and the pattern frame so that the sheet of stock will be well lighted. Also, the lamp itself must be well out of the way to allow free passage of the stock from the left-hand table to the one on the right. The fixture shown complies with all these conditions. In this case it is a twin fixture, one light being fastened at each side of the machine, the pipes meeting at a common feed pipe in the back of the machine.

The form of fixture shown at *C* is quite simple. The difficulty of lighting this sewing machine was that the fixture must not be installed rigidly, because it is necessary to tilt the machine back to make adjustments. To meet this condition a ⅜-in. drop L condulet was reamed clean of its threads and screwed to the bench, as a footing to support the fixture. The upright of the fixture was ground with a slight taper at its lower end, and then simply given a twist fit into the reamed footing. When the operator wishes to tilt back the machine, it is merely necessary to pull the fixture out of the footing and place it out of the way.

The recording thermometers, shown at *D*, were originally lighted from above. Since the recording arms are pivoted from the tops of the instruments, this first form of lighting threw a shadow down from the point of the pen. These pen points are used as indicators, and by means of control valves they are made to trace over a predetermined curve on the chart. With the shadow at the point of the pen it was really difficult for the operator to follow this curve closely, simply because he could not accurately note the true position of the indicator. To overcome the dark spot, the lights were installed so that the instruments are illuminated from below, the shadows from the pen points being thrown upward and away from the point of observation. After this change was completed, a marked improvement in the curves immediately resulted. Other machines having dark spots may also be similarly illuminated.

JAMES P. MARSHALL.
Electrical Engineer,
Bourn Rubber Mfg. Co.,
Providence, R. I.



This shows how dark spots were illuminated on the platen of an eyeletting machine at *A*, on a sole-cutting machine at *B*, on a sewing machine at *C*, and on recording thermometers at *D*.

Heavy Oil on Rotor Cause of Unusual Motor Trouble

THE sudden change in weather one night from warm to chilly was the cause of an uncommon trouble on a 15-hp., three-phase, 220-volt motor driving the lineshaft in a small foundry. This motor started star and ran delta-connected—that is, it had a star-delta connection on the outside of the stator for starting purposes. This ar-

rangement gives approximately the same result as an auto starter connected on the 65 per cent tap, which connection results in a very low starting torque.

When it was found that the motor would not start, the belt was removed from the motor pulley. The owner of the place could not turn the rotor; so he took the endbells off the motor, and as they turned freely, he was certain that the bearings were not stuck. The motor bearings were fitted reasonably tight, so he was at a loss to know what was causing the trouble.

When I arrived, I asked the owner how his motor acted when it had run last and what had been done to remedy the trouble. He said it had run until 9 o'clock the night before; then he had shut it down himself. There was plenty of oil in the bearings and they were all right as far as he knew. I closed the starting side of the switch, but it only caused the motor to hum. Closing the running side of the switch gave the same result.

The fuses were found to be in good condition; so I shut down all the other motors on that line and tested it with a 220-volt test light. The light burned brightly on all phases. My reason for shutting down the other motors was to prevent current being fed back in the blown fuse line by any other motor, for in this case the test light would burn on all phases, even though a fuse were blown. The motor bearings were tested again and found to be OK, so the end frames were removed entirely. Two helpers had considerable difficulty in trying to remove the rotor, but after examining the rotor and stator to see if something had wedged between them, more force was applied to the rotor and it came out.

It was found that the surfaces of the stator and rotor were covered with a stiff paste something on the order of dough. They were given a good gasoline bath, after which the rotor was assembled and the motor ran perfectly.

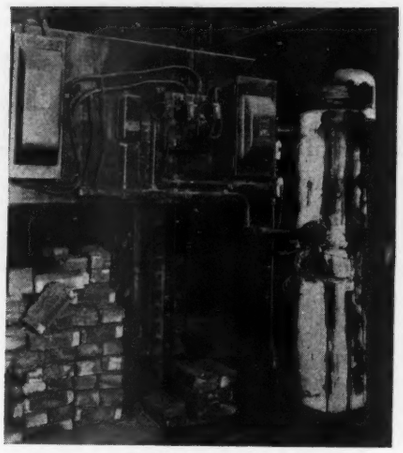
A little study showed that an excess amount of oil that had been poured into the oil wells had overflowed onto the rotor. This oil, mixed with the foundry dust, made such a heavy paste that when the weather turned suddenly cool, it prevented the rotor from turning.

GRADY H. EMERSON.

Method of Preheating Fuel Oil Electrically

THE efficient combustion of fuel oil depends, to a certain extent, upon maintaining a constant fluidity of the oil at the burners, and the fluidity, in turn, depends upon the temperature of the oil. According to C. J. Carrigan, of the Phoenix Rolls Corp., Pittsburgh, Pa., two electrically-heated oil heaters are used for preheating the fuel oil used in their open hearth furnaces.

Each of these heaters consists of a cylindrical tank, 10 in. in diameter by 96 in. high, and 32 Westinghouse space heaters, arranged around the tank, heat the oil. The oil temperature is automatically controlled by means of a bimetallic thermostat mounted on the side of the oil tank, through a motor-operated snap switch and a contactor. The oil, which is circulated by a motor-driven pump, enters the heater at the bottom and leaves from the top. The capacity of each heater is sufficient to heat 100 gal. of oil per hr. to 180-210 deg. F.



The oil is heated by passing it through these tanks which are fitted with space heaters, mounted on the outside.

A constant temperature is maintained by means of a thermostat which serves to open and close the heating circuit through a motor driven switch and contactor.

One of the chief features of this method is that the control apparatus keeps the temperature of the oil at the desired point without any attention on the part of the operators. By using these preheaters more efficient combustion in the open hearth furnaces is obtained, with a resultant saving in the cost of fuel.

Causes and Remedies for Some D. C. Motor Troubles

MOST d. c. motor troubles center around commutation and trouble is generally signalized by heavy sparking at the brushes.

Usually a small amount of sparking does not harm the commutator bars, but if it should, the cause of the sparking should be removed at the earliest opportunity. Small, noiseless, whitish-colored sparks on the edge of the brush are harmless. Sparking at irregular intervals, accompanied by a green flame and a hissing sound, is due to small particles of copper that have been disintegrated by continuous overheating, and will in a very short time cut a furrow around the commutator, and bits will adhere to the brushes. While an overload may in some cases cause excessive sparking, this is not usually the primary cause. Most reliable makes of motors are guaranteed for a 50 per cent, and with some makes 100 per cent, momentary overload. However, to allow an appreciable overload to remain, is a clear case of abuse, and the motor will naturally overheat.

Should there be sufficient overload on the motors to cause excessive sparking, some relief may be obtained by shifting the brushes, but the overload should be removed as soon as possible.

When the motor is not overloaded, we may look for the cause of sparking in the brushes. Shifting the brushes backward and forward may diminish sparking, or the cause may be due to incorrect spacing of the brushes. In order to determine the correct spacing of the brushes, apply the following rule: Total number of commutator bars divided by number of poles equals the number of commutator bars allowable between the edges of two adjacent brushes. When a good brush contact is being made, the commutator will assume a smooth, glassy surface with a rich chocolate color and the contact surface of the brush will be smooth.

In the event that the composition of the brushes is too soft or too hard, this fact will show itself in the surface of both the commutator and the brushes. If the surface of the brushes and commutator appears rough, and ploughed up, with specks of metal attached to the brushes, the latter may be immersed in a bath of hot petroleum jelly and boiled for a time, after which they should be thoroughly cleaned and dried. Fine sandpaper should be drawn between the commutator and each brush, with the rough side of the paper against the brush, to reseat it.

The commutator surface must be kept clean and glossy at all times. If it becomes roughened up as mentioned above this can be remedied by the use of a commutator stone or sandpaper held against the commutator with a wooden form. Care should be taken that all dust and abrasive material is removed before putting the motor into service again. Grease should be kept away from the commutator. Where this is hard to avoid, as in oil well drilling and pumping, a totally-enclosed motor is often used, which obviates this trouble.

Should the commutator become eccentric, nothing can be done for it while in service; it will be necessary to put the armature in a lathe and true up the commutator with a turning tool.

Other causes of sparking, such as grounds, open circuits and short-circuits, may be detected by test instruments.

Overheating may be due to several conditions, among which are poor bearing surfaces that cause excessive friction. Faulty lubrication is often the cause of this condition. The oil used in motors must be of the best quality, and adapted to the service conditions. Sometimes in a small plant, an oiler will use, regardless of its condition, old oil that may have been taken from the overflow of other machines. Where there are a large number of motors, it is economy to have a reputable oil company send in an expert to recommend the proper oil to use on each motor. Although this means that the oil company naturally expects that its products will be used, it has been my experience that this procedure will save trouble. This method of handling lubrication problems should likewise be applied to all mechanical equipment.

Shafting that is out of line, or tight belts will also cause heating, and the remedies are obvious.

All connections should be periodically tested out and tightened if necessary,

especially in the case of motors that are mounted on slide rails for adjustment, where any looseness will set up a vibration. Should a motor by any chance be thoroughly wetted by rain, or through the bursting of a pipe, or other mishap, no attempt should be made to run it, on the chance that it will dry out. It should be taken down and thoroughly dried out in the oven first. This may appear to be unnecessary, but it is cheaper than having coils burn out.

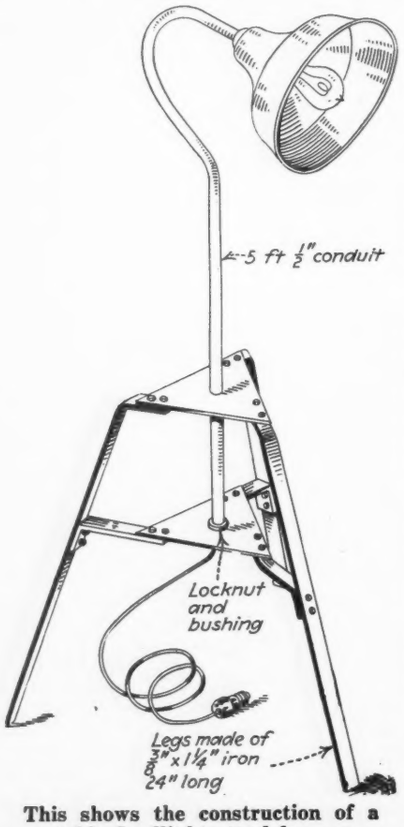
M. C. COCKSHOTT.
Hollywood, Calif.

Inexpensive Portable Floodlight for Temporary Use

IT SUDDENLY became necessary to construct some sort of a temporary lighting system at the plant where the writer was employed in order to rush night work on an excavation job. Floodlights were out of the question, as the night work would not continue very long. To meet the emergency, the plant electrician made up the lamp reflector and stand for holding it, shown in the accompanying illustration.

The total cost of each stand was $4.18, as shown in the accompanying itemized cost list of the various parts needed.

The two triangular-shaped pieces of iron used in the stand are ⅜ in. in thickness and were sheared from a piece of scrap iron. A 250-watt lamp is supplied with each stand, thus completing the lighting unit. Due to three legs being used rather than four, the lamp stands firmly, even though placed on rough ground. These outfits are light and easily moved from place to place, and yet they are strong and rugged enough for almost any purpose.



This shows the construction of a portable floodlight stand for use on a temporary job.

Cost of Floodlight Parts

Item	Cost
Reflector	$1.60
Socket	.30
Locknut and bushing	.06
5 ft. ½-in. conduit	.35
6⅝-in. x 1-in. bolts	.18
6¼-in. x 1-in. stove bolts	.12
6 ft. ⅝-in. x 1¼-in. flat iron	.42
3 short pieces of strap iron	.05
12 ft. No. 14 wire and plug	.20
Labor	.90
Total Cost	$4.18

Electrician, CHAS. A. PETERSON.
Fairbanks Exploration Co.,
Fairbanks, Alaska.

Simple Commutation Troubles Often Caused by Neglect

AS ONE example of how an apparently easily detected commutation trouble will often mislead the operator into believing that his difficulty is caused by a defect not at the commutator, an experience that I had while calling on an operator friend is interesting. He looked for winding troubles as a cause of poor commutation, when the trouble actually was caused by the entire set of brush springs, which had been in use so long that their elasticity had nearly disappeared.

This permanent set in brush springs may also be caused by giving the brush rigging so little attention that the pigtails cease to carry current, this duty being transferred to the brush springs which become heated occasionally when there is a heavy load on the machine. This heating draws the temper of the springs. If the spring tension behind the brush does not act quickly and constantly in maintaining the brush pressure on the fast-moving commutator bars, good commutation cannot be expected, of course.

I have observed many generators where the brushes underneath the commutator have had little attention because they were hard to get at, although thorough cleanliness of the parts that comprise the brush-holder is essential. As an aid in cleaning commutators several non-inflammable liquids are on the market that have all the grease-absorbing characteristics of benzine but none of the fire hazards. These liquids may be used with a stiff, clean paint brush to wash the dirt and accumulated grease from the brush-holders, thus maintaining a free movement of the brush-holder parts so that everything will be in readiness to handle the peak demands on the machine.

Collector rings usually are so free from troubles that the glaze on them is frequently unnoticed, but I have observed a.c. slip-ring motors connected to intermittent start-and-stop apparatus, like elevators, where the removal of the glaze from the rings reduced the time of acceleration 40 per cent, thus saving considerable power and adding to the efficiency of the apparatus as a whole. It pays to watch commutators and slip rings carefully.

Manager, WILLIAM L. WEBER.
Acme Abrasive Co.,
Chicago, Ill.

Comments on "Planning Distribution System"

THE article by Marin Phillips in the January issue of INDUSTRIAL ENGINEER was very interesting. However, I should like to say, relative to his statements on making splices and taps in junction boxes, that I prefer the use of Dossert, Frankel or similar cable connectors.

Although it is perfectly true that hand-made splices, taps, and pigtails have been in use for many years, there is no question that the types of cable connectors mentioned above save a great deal of time, especially when changes are to be made in the wiring system of a plant. In an industrial plant that is growing rapidly there are usually frequent changes in, or additions to, the electrical equipment. If this point is kept in mind when an installation is made, future changes will be much easier to handle.

When this type of connector was introduced I was rather skeptical about such devices giving satisfactory service, but have now used them for several years without ever having any trouble due to heating of the joints.

Mr. Phillips's practice of using lugs in making splices is good. I know from personal experience that this method gives very good results and that such joints are much better and easier to handle than a soldered splice when changes are to be made.

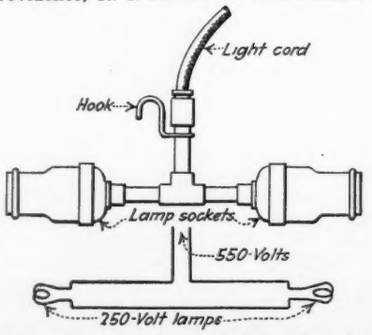
Electrician, CHAS. A. PETERSON.
Fairbanks Exploration Co.,
Fairbanks, Alaska.

How to Make Handy 550-Volt Test Lamp Holder

THE test lamp holder shown in the accompanying sketch will, perhaps, prove to be a welcome departure from the usual cumbersome lampbank. Its construction is simple, the required materials consisting of three ⅝-in. short nipples, one ⅝-in. tee, one ⅝-in. coupling, one ⅝-in. composition socket bushing, and two sockets, assembled as shown in the accompanying illustration. A hook made of strong wire and fastened to the nipple just below the coupling will be found useful, since it will allow the user to hook the tester onto his belt, thus leaving both hands free for other work.

The 250-volt test lamps used in this holder should be connected in series, as shown.

Providence, R. I. JAMES P. MARSHALL.



Here is a test lamp holder that is inexpensive and easy to carry around.

Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Supporting Double Row of Shafts from Building Column

RECENTLY in a visit to an industrial plant, the writer had the good fortune to observe the erection of two lines of shafting in a steel building where the construction presented unusual difficulties. This was a steel and glass, single-story building that was being changed from dead storage purposes to a machine room.

The building had a row of columns of Bethlehem H-beams down the center and a clear floor space of 60 ft. on each side. The columns were joined about 16 ft. from the floor by the 12-in., 31-lb. steel I-beams *A* and *B*, shown in the accompanying sketch. These beams were riveted to short sections of angles or brackets which, in turn, were riveted to the columns. This construction was amply strong enough for its original purpose and also was able to carry a reasonable amount of additional weight.

The plan used in fitting up the building for production was to arrange the machinery in a double row down the center of the building, with a row of machinery on each side of the column. The machines were thus compactly placed and close to the only feasible location for suspending an overhead structure to support the lineshafts. This left a large part of the floor space in the two bays available for other work. The layout included a single length of 300 ft. of lineshaft and an equal length spaced off into several smaller group drives for some machines.

The method of suspension used was rugged and simple. Its basic unit was a short length of 12-in., 31-lb. I-beam, *C*, bolted to the pair of longitudinal beams *A* and *B*. This short beam *C* was placed against the side of the H-column and bolted to each side of the lower flanges of *A* and *B*. The beam *C* was thus suspended by the bolts. It would have been better practice to rest them on top of the longitudinal beams and have the bolts serve only for holding the beams in position, but other structural features of the building prevented this. Also, there would have been some disadvantage in this case from raising the shafting higher.

Instead of bolting the hangers to the stub beams *C*, as might have been done, a pair of timbers or stringers was run the full length of the building on each side of the H-column and bolted to *C*. The hangers were then bolted to the stringers. Some of the advantages of this plan included reduced likelihood of breaking the cast-iron hangers if rough hangers were bolted to the steel flanges of the I-beams, the ability to space the hangers where desired instead of mounting on the column centers, easier erection, and so on.

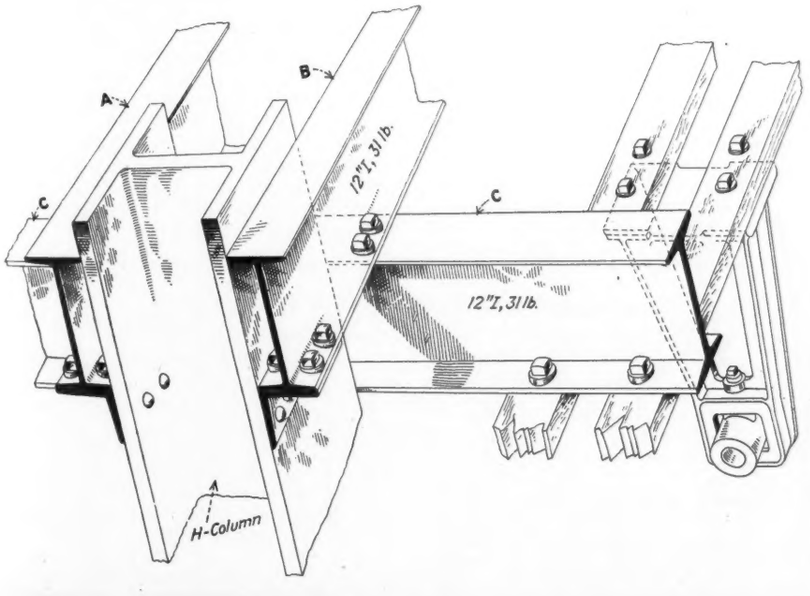
The driving motors were placed on top of the steel I-beams *A* and *B* on wooden sleepers positioned to suit the drives.

This method of support has much to commend it. The single rows of shafts on each side of the column form a balanced cantilever suspension that adds but little stress to the building structure. There is nothing in the construction which would be in the way of cranes, should these be installed later. This construction is not expensive, in that there are few holes to drill in the permanent structure. Also, the layout is economical of light and floor space.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Using cantilever support for a double row of lineshafting.

When a building is not planned for production it is frequently necessary to use ingenious methods for supporting lineshafting. Here short, cross I-beams *C* are fastened to the pair of longitudinal I-beams *A* and *B*, and a row of shafts suspended from each end. These shafts serve two rows of machinery. The motors are mounted on wooden sleepers supported on the top of *A* and *B*. Another row of shaft hangers is attached to the cross beams *C* at the left end, although they are not shown in this drawing.



Using Oxyacetylene Torch When Relining Bearings

NOT only is the oxyacetylene torch useful for welding and cutting around the industrial plant, but it can also he used as a source of heat for removing babbitt from old bearings and also for babbitting according to the Smith Welding Equipment Corporation, Minneapolis, Minn. The flame is easily adjusted to the proper temperature and saves much time in melting out the old metal and burning off the grease for cleaning the bearing mold. The tip used need not be large and should be kept in motion by playing over the old metal until it is all melted out, but care should be taken not to burn the metal. Playing the torch flame over the mold will burn out the oil or grease and any other foreign matter, and dry up the bearing so that a wire brush will clean it perfectly.

Preheating the bearing mold for a new lining is a most important part of the work, because the babbitt will not adhere to cold metal. The difficulty of heating and then placing the bearing in place for the pour is well known to anyone having this work to do. Using the torch simplifies the work to a great extent, because with it the mandrel or shaft can be warmed up and the bearing molds heated while in place. The melting pot should then be heated, and

after adding metal, the heat for melting is supplied by playing the torch flame on the bottom of the pot. Any desired temperature of bearing mold and pot metal can be obtained and a perfect pour made.

Often a worn or scored bearing can be repaired with the torch. The lining must first be washed with lye water and all traces of oil removed. By using a filler rod of babbitt metal, the scores are built up and the bearing can then be scraped in. Building up worn brasses and babbitt metal bearings requires skillful manipulation of the torch. Spots are built up and allowed to solidify; the welder works each spot toward the center of the bearing and finally completes the welding work at this point.

Making a weld near a bearing will often necessitate repouring the bearing unless some precaution is taken to prevent the soft metal from melting. Frequently repouring can be avoided by placing a piece of pipe, approximately the size of the shaft, in the bearing and circulating water through it.

The valve gear on feed pumps wears out constantly and probably gives more trouble from lost motion than any other part of the plant equipment. The easiest and quickest method of repairing is to fill up the valve rod heads with steel or bronze by using the torch and drill out for the pin.

Worn bearings in the crosshead stand can be repaired best by welding in cast iron to a depth of 1 in. and drilling out for the rocker shaft. It will be necessary, in order to fill up the old bearing space, to back it up with asbestos or carbon paste.

In one case, the partition between the valve chambers on a feed pump had become so pitted that the gasket would not hold, although the remainder of the pump was in excellent shape. This part was built up with bronze, which was dressed down by hand, and has been in use two years without replacing a gasket.

Some Recent Developments in High-Speed Chain Drives

IN A comprehensive paper, carrying the above title and covering the application of chain drives, which was read at the recent meeting of the American Gear Manufacturers Association at Briarcliff Lodge, Briarcliff Manor, N. Y., George M. Bartlett, Chief Engineer, Diamond Chain and Manufacturing Co., Indianapolis, Ind., brought out the following interesting points on chain drives. The technical discussion and formulas are omitted in this summary.

"The behavior of a chain drive of the so-called silent, inverted-tooth, or roller type is affected by such primary conditions as sprocket speed, horsepower, center distance, and number of teeth, and such secondary conditions as chain velocity, pull, length, angle of bend of links, weight of links, and projected area of rollers. Other influences are centrifugal force, friction, inertia and impact.

"To illustrate some of these effects, let us assume that a sprocket has its tooth number changed from 12 to 24, the revolutions remaining the same. The pull then becomes only half as great, if transmitting the same power, and each link turns an angle half as great, although there are twice as many bends per minute. The chain length increases, considering that the center distance remains constant, and the wear is thus divided among more links; in fact, it is only four-elevenths as great in the latter case as in the former, and the life of the chain is multiplied by 2¾.

"The wear on the chain pins has been found to be proportional to the angle of bend times the bends per minute times the chain pull, divided by the number of links in the chain. The life of the chain is, therefore, proportional to the product of the number of teeth multiplied by the chain length in inches.

"It might appear that when the chain velocity is doubled, assuming constant r.p.m., the rollers must approach the sprocket with twice the velocity. However, the impact between the rollers and the sprocket teeth does not take place in a direction parallel to the chain travel but perpendicular to it. Hence, the velocity of impact is proportional to the angular velocity of the approaching link about its pin, which is in turn equal to the angular velocity of the sprocket itself and is, therefore, independent of the number of teeth or of the chain velocity.

"Under high lineal velocities there are three factors that may affect the correct action between the chain links and the sprocket teeth: inertia of the individual links, viscosity of the lubricant surrounding the pins, and centrifugal force. Because of the first two factors, the chain appears to resist the act of unwrapping, but this condition seems to have no ill effect upon the drive even at high chain velocity. The sprocket teeth have no part in this phenomenon, since the same thing occurs when the chain is simply wrapped around a smooth pulley.

"We may say that centrifugal force is probably the only factor that produces a measurable effect on the action of the chain at high lineal velocities. A small amount of slack in the chain is usually desirable, but where the velocity is high centrifugal force affects the correct action near the point where the pull is low and it is necessary to take up most of the slack in order to avoid the tendency of the rollers to 'top the teeth.'

"While the lineal velocity of the chain has little effect upon its operation, the rotating speed of the sprocket is a determining factor, since it directly affects the impact between the chain and the sprocket. The velocity of impact is independent of the number of teeth, or of the angle of bend of the link, or of the chain velocity. Instead it depends directly upon the r.p.m. of the sprocket and the pitch of the chain. The energy of impact between the roller and the sprocket is proportional to the weight of the chain link and to the square of the velocity of impact, while the destructive action between a roller and sprocket is proportional to the energy of impact divided by the projected area of the roller. The velocity of impact, on the other hand, is proportional to the r.p.m. of the sprocket and also to the chain pitch.

"By a study of the mathematical analysis of this problem, it is evident that in order to attain high sprocket speeds the pitch must be kept short, the weight of the chain low, and the roller area high. When the proper formula is applied to the standard series of roller chains, the maximum speeds shown in the accompanying table are obtained. The sprocket speeds shown in the third column are the highest advisable speeds for any type of chain, whether roller or tooth type, and in actual practice the speeds are usually not more than 75 per cent of those given in the table.

"In order to use a short-pitch chain for high speeds and at the same time transmit an appreciable load, it is necessary to provide a special type of roller chain designed for light weight, short pitch and large roller area. To do this it is only necessary to build up standard roller chains of short pitch in double, triple and quadruple widths, and to give proper attention to accuracy and precision of manufacture of the chain parts, including uniform heat-treatment of the bearing surfaces.

"Obviously, precision in this design is important because of the multiple width. With such chains it is possible to transmit two, three and four times as much power at a given speed as was formerly the case, and it is also possible to transmit a given amount of power at three or four times the speed in r.p.m. as is possible with single-width standard chains. Such chains operate much more quietly than do chains of single width. Some chain drives are noisy because of the acoustic conditions connected with the installations and some parts of the mounting may act as resonators."

Maximum Sprocket Speeds for Roller Chain

Chain No.	Pitch, In.	Max. R.P.M.	Average Horsepower		
			Single	Double	Triple
30W	⅜	3,600	1.5	3	4.5
40W	½	2,600	2¼	4.5	6.75
50W	⅝	1,900	3½	7	10
60W	¾	1,500	5	10	15
80W	1	940	0	18	27
100W	1¼	645	13	26	39
120W	1½	520	19.5	39	58
140W	1¾	370	23.25	36.5	69.5
160W	2	325	31.5	63	94.5

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Method of Cutting Mica Segments for Commutators

THE article by C. B. Keck, entitled "Method of Cutting Mica Segments to Save Time and Waste of Material," on page 341 of the July issue of INDUSTRIAL ENGINEER, called to mind the procedure followed in a certain large repair shop.

The sheet mica is first cut into strips the full length of the sheet, the width of the strips being equal to the length of the commutator bars. Square edges are essential so care must be taken in cutting the strips. After cutting into strips on a strawboard cutter, the mica segments are cut off.

The dotted lines in Fig. 1 *II* indicate the positions that the commutator bars would assume if they were laid upon the uncut mica strip.

By drawing a line through the points, *X* and *Y*, in diagram *I* of Fig. 1, the waste material space, as shown in Mr. Keck's article, will be cut by a diagonal line. The point *X* is located by measuring $\frac{1}{16}$ in. above the front top corner of the commutator bar neck, and *Y* is located by measuring $\frac{1}{16}$ in. above the top of the front end of the bar.

Cutting out a mica blank for a segment requires only two operations of the cutter, the first cut being made along line *X-Y* and the second cut on line *E-F*.

The greatest amount of waste occurs with the high neck type of bars. Assume that Fig. 1 *I* shows a high neck bar for which we are to cut new mica strips. This bar is 7 in. long by $2\frac{3}{4}$ in. high, the neck being $1\frac{1}{4}$ in. high by $\frac{7}{8}$ in. wide. The height of the bar in the front and the rear is $2\frac{3}{4}$ in. and $3\frac{1}{4}$ in. respectively. These dimensions can be taken directly from the bar.

Fig. 2 *I* shows the method of setting the straight edge and protractor arm on the table top of the strawboard cutter. First, measure back along the straight edge from the edge of the stationary knife a distance *A* which is equal to the dimension *A* in *I* of Fig. 1, thus determining the position of point *D*, Fig. 2 *II*. From point *D* measure along the protractor arm a distance *L* which is equal to the distance *B* in Fig. 1 *I*. A paper templet can be used in place of the commutator bar although the best method, after one gets used to it, is to place the commutator bar on the table top, arranging the protractor arm so that the correct angle and distances *B* and *A* are obtained, as in Fig. 2 *I*.

Fig. 2 *II* shows how the strips are fed into the cutter to make the first cut. The front edge of the strip is pushed flush against the protractor arm and one corner to point *D*, which is the intersecting point of the straightedge and the protractor arm. The shaded portion *C* shows the location and the shape of the segment that the first cut makes.

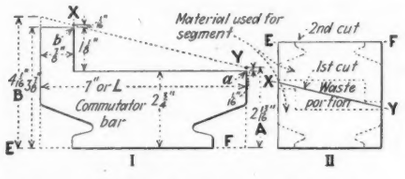


Fig. 1—This shows how mica segments can be cut with a minimum of waste.

I represents a typical commutator bar which serves as a pattern for the segments. The mica is first cut into strips. These are then cut, as shown in *II*, into pieces each of which will make one segment.

To make the second cut the mica strip is turned over 180 deg. then the mica strip corners *G* and *H* in *II* of Fig. 2, assume the positions indicated in *III*, Fig. 2. In this diagram *C* indicates the portion of mica strip obtained from the second cut.

Notice that with the first cut the end of the mica strip is held against the protractor arm and the cutter makes a diagonal cut through the strip, but when the strip is flopped over for the second cut, the diagonal end is against the protractor arm and the cutter makes a straight line cut across the strip, as shown in Fig. 2 *III*.

To make the third cut, the strip is fed into the cutter as shown in *II* of Fig. 2. The fourth cut is made in the same manner as was the second, and so on until all the strip has been used.

Where a bandsaw is available, a simple and quick method of procedure is to cut the mica sheets into strips as previously described, and then shellac the bars to the long mica strips. Place the bars as shown in Fig. 1 *II*. After the shellac has set, the long strips may be cut at *X-Y* and *E-F* alternately. A saw should be used which has very little set. Copper saws are sometimes used for this work.

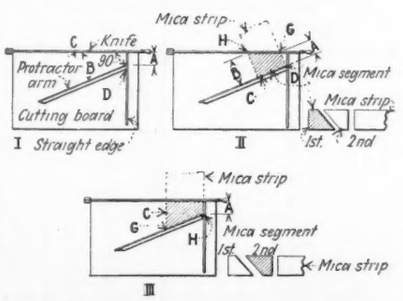


Fig. 2—How the mica strips are placed for cutting.

The protractor arm is adjusted as shown in *I*, prior to making the first cut. The position of the strip for the first cut is shown in *II*. For the second cut the position of the strip is reversed, as indicated in *III*.

After cutting the strips, the mica around the bars, including the V's, can be cut away. The workman must be cautioned not to cut within $\frac{1}{32}$ in. from the copper bar. After placing the bar and mica in a vise, this $\frac{1}{32}$-in. strip can be removed by using a knife file.

A. C. ROE.

Renewal Parts Engineering Dept., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Factors in Rewinding Motors for Different Frequencies

WHEN changing an induction motor to operate at a different frequency, several points should be considered. Since frequency has a direct effect upon the speed of an a.c. motor, it is necessary to make sure that the motor speed will remain within safe limits after a change in frequency has been made.

The cause of this change in speed, with the voltage remaining the same, is due to the change in the velocity of the rotating magnetic field. The rotating magnetic field varies in direct ratio and in the same direction as the change in frequency. With a constant magnetic flux, the electromotive force generated depends upon the rate at which the wires cut through the magnetic field. Therefore, by changing the frequency, the emf. generated is changed in the same ratio.

If the flux density and torque are to remain the same for the new frequency, the applied voltage must be changed in the same ratio as the change in frequency. The new values for the speed, voltage and horsepower ratings, can be expressed as follows: New speed = original speed × (new frequency ÷ original frequency); new voltage = original voltage × (new frequency ÷ original frequency); new horsepower = original horsepower × (new frequency ÷ original frequency).

If a motor is operated, without reconnection, on a higher frequency than that for which it was designed, the voltage, speed, horsepower and heating effect must be given consideration.

It has already been shown that, if the operating characteristics of a motor are to remain the same after a

change in frequency, the applied voltage must be changed in the same ratio. Thus, if a 30-cycle, 220-volt, 15-hp. motor is operated on a 60-cycle circuit, the new voltage should be: $220 \times (60 \div 30) = 440$ volts. The new horsepower rating will then be $15 \times (60 \div 30) = 30$ hp. If the connections to the load were changed so that the speed of the driven machine remains the same, the motor would operate at, $15 \div 30 = 0.50$, or 50 per cent of full-load capacity, and besides causing a decrease in the power factor, the efficiency of the motor would also be decreased.

An increase in frequency not only causes an increase in the hysteresis and eddy current losses, but it tends to increase the temperature of the machine. Although the increase in speed will improve the ventilation of the motor, it is a question whether or not the increased heating due to the hysteresis and eddy current losses in the iron will be balanced by the increase in ventilation, for much depends upon the design of the motor.

The peripheral speed of the rotor should not exceed 7,000 ft. per min. (without consulting the manufacturer). The peripheral speed is computed by multiplying the circumference in feet by the r.p.m.

If a motor that is designed to operate on a 25-cycle circuit is operated on a 60-cycle circuit, its speed will be increased $60 \div 25 = 2.4$ times the original speed. The rotor will have to be checked to see if the end rings have the proper resistance in order to give the desired starting torque without taking an excessive starting current.

When the frequency is raised, the resistance of the short-circuiting rings at the end of the rotor windings must be increased so as to maintain the same relative value of starting torque to full-load torque and, conversely, when the frequency is decreased, the resistance can be reduced, which cuts down the rotor copper loss and the heating.

Indianapolis, Ind. M. V. MILLER.

Opening Armature Slots Raised Speed of D.C. Motor

IN A case that I know of the slots in the core of a direct-current motor armature were opened up to permit form-wound coils to be installed in place of an old hand winding. When the job was finished, the motor running speed was 120 per cent above its normal running speed before rewinding.

To reduce the speed to normal, it was considered advisable to fit thin iron shims on the field pole shoes. This shimming up caused a stronger magnetic field and a reduced armature speed. The speed of the motor in this case might also have been reduced by winding a few more turns on the field coils. These extra turns would also cause a stronger field and a lower armature speed; or the field coils might have been supplied with current at normal voltage while the armature and the series winding were supplied with current through a resistance. This latter method would, however, be inefficient and wasteful.

W. E. WARNER.

Shefford, Bedfordshire, England.

Some Handy Winding Tools That Are Easy to Make

SEVERAL tools which I have found very handy for the armature winder are shown in the accompanying illustration. Even though many armature winders use tools similar to the ones that will be described, I have seldom noticed such tools advertised for sale. Tools of the sizes shown are intended to be used on medium-sized winding jobs, but, of course, the winder can easily have larger or smaller tools made in a machine shop, so that they will fit the average job that he customarily works on.

The drift shown at *A* in the accompanying illustration should be made preferably from horn fiber. This coil drift is used to shape the coils after they are in the slot, especially when the coils are difficult to get at.

At *B* a cell paper cutter is shown, which can be made from a 6-in. file. After taking the temper out of the file, and grinding off the teeth on an emery wheel, cut a V-shaped slot about $\frac{3}{8}$ in. long in the end.

Next, heat up one end of the file red hot and bend it as shown in the illustration. Sharpen the cutting edge of the V, and after the end of the file has been tempered, the cutting edge should be resharpened with a stone so that it has an edge that will cut like a razor.

The packing tool shown above tool at *D* is used in pushing and packing the coils in semi-closed slots. A file may be used to shape a piece of soft iron but a better tool can be made by shaping a piece of steel on a planer.

A cold chisel or a punch flattened out on the end and shaped as shown at *D*, and then tempered, will be found very handy in lifting coil leads out of the commutator segments without heating the soldered connections.

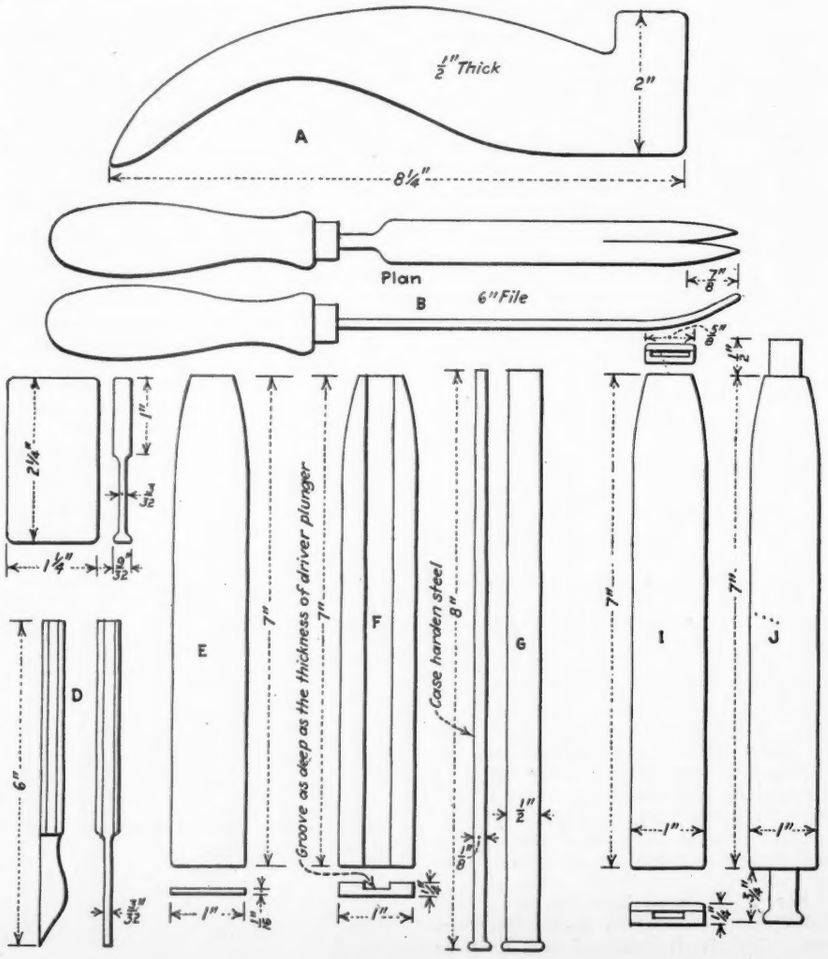
The wedge-driving tool shown at *J* is used to drive retaining wedges in the slots. This tool is a great time saver, and does the work much better than any other method than I have employed. The tool is all made out of steel and the various steps involved in the making of it are shown in illustrations *E* to *J* inclusive. The piece shown at *E* is placed on top of *F* and welded or brazed. The pieces shown at *G* must work very freely in the slot shown at *I*. The tool is shown assembled at *J*.

H. J. ACHEE.

District Line Supt.,
Southwest Light & Power Co.,
Elk City, Okla.

These tools will save time and trouble on difficult jobs.

A coil drift, made preferably of horn fiber, is shown at *A*. The cell paper cutter shown at *B* is made from a 6-in. file. The tool shown above *D* is used to push and pack coils in semi-inclosed slots. A tool which is handy for lifting coil leads out of commutator segments without heating the soldered joints is shown at *D*. The various steps necessary in making the tool shown at *J* are illustrated at *E*, *F*, *G*, and *I*.



New Equipment

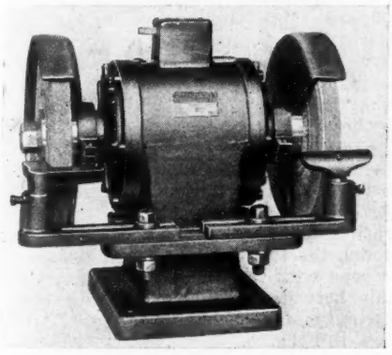
for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Ball-Bearing Bench Grinder

PRODUCTION of a line of ball-bearing bench grinders in ¼-, ½-, 1- and 2-hp. sizes is announced by the Standard Electrical Tool Co., 1938 West Eighth St., Cincinnati, Ohio. One of the units is shown in an accompanying illustration. This grinder has integral motor drive and is for use on either alternating or direct current. The armature shaft, which also carries the grinding wheels, is made of nickel steel and rotates in ball bearings mounted in dustproof housings.

The switch is located on top of the motor housing, and is of the quick make-and-break type. The wheel sizes range from 6 to 12 in. in diameter. Adjustable arms for tool rests are available in various types, and both rests and arms are detachable. These grinders are also manufactured in the pedestal type.



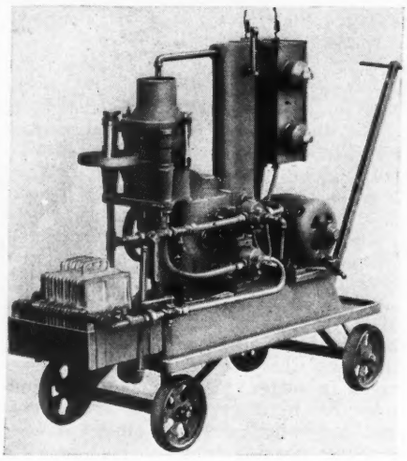
Standard Electrical Tool Co., Ball-Bearing Bench Grinder.

Hydroil Continuous Oil Purifier

ANNOUNCEMENT has been made by the Hydroil Sales Corporation, Lebanon, Ind., of developments and improvements in the portable Hydroil separator, which is a centrifugal separator of the bowl type for cleaning and dehydrating insulating oils, by the addition of a filter. This machine, it is stated, is designed and built especially for use in connection with the purification of insulating oils. One of the new model portable units is shown in an accompanying illustration.

This unit consists of a centrifugal separator, which is mounted on a platform, together with its motor, pump, immersion electric heaters to raise the temperature of the oil to the point where the most complete dehydration is obtained, and control equipment for the motors and heating equipment.

This new model is provided with a filter press for use in dehydrating and cleaning circuit breaker and switch oils. This filter press is shown attached to the rear end of the equipment. In use, the centrifugal dehydrator removes the water, and the filter press takes out any carbon particles or other impurities that may pass through the dehydrator. It is stated that because the water has already been removed, the filter sheets do not get wet and so do not have to be changed as frequently as when used to remove both water and impurities. This equipment is connected by a valve arrangement so that the filter press may or may not be used, as desired.



Hydroil Portable Continuous Centrifugal Oil Separator with Filter Press.

In the purification of transformer oil, the unit, according to the manufacturer, may be connected to the transformer chamber to circulate the oil through the dehydrator and filter if necessary, and back into the transformer, or into a storage chamber, as desired. The capacity of the unit shown is 100 gal. per hr. Two 3-kw. standard immersion heaters and a ¾-hp. ball-bearing motor are used. Rubber-tired wheels are used on the new unit.

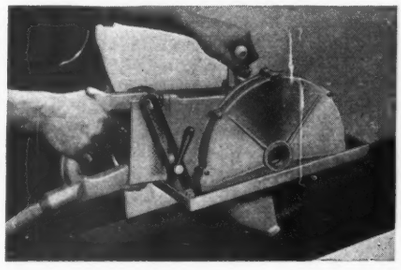
Power Handsaw

MANUFACTURE of a portable electric handsaw for use on construction jobs and in industrial plants, is announced by the Wappat Gear Works, Market St. at Braddock Ave., Pittsburgh, Pa. The saw, which is shown in an accompanying illustration, is distributed under the trade name of the Alta Power Saw. It is claimed that one man with this saw can, in a given time, cut as much lumber as ten men with ordinary handsaws. Heavier material that must ordinarily be carried to a table saw can be cut off or ripped with this portable saw, thereby reducing handling time. The saw is equipped with a 9-in. blade and cuts 3-in. material.

The outstanding feature of the Alta saw, according to the manufacturers, is the safety guard. A circular saw, whether idle or revolving, is dangerous. The blade on the Alta saw is completely enclosed by a telescopic guard which automatically opens only when the saw is pushed into the material and automatically closes again when the cut is completed. This guard serves both to safeguard against accident and protect the blade from damage.

The wide carrying shoe supports the tool and prevents tipping, thereby limiting the operator's effort to mere guiding. A blast of air from the motor ventilating fan is directed to the front of the saw to blow the sawdust away. The shoe is adjustable, so that it is possible to set the saw for any depth of cut.

A ¾-hp., 110- or 220-volt, universal-type motor which operates from an a.c. or d.c. power socket, is used. It is stated that the Timken tapered roller bearings and the worm gear drive result in quiet operation and a minimum of wear.



Portable Alta power handsaw manufactured by the Wappat Gear Works.

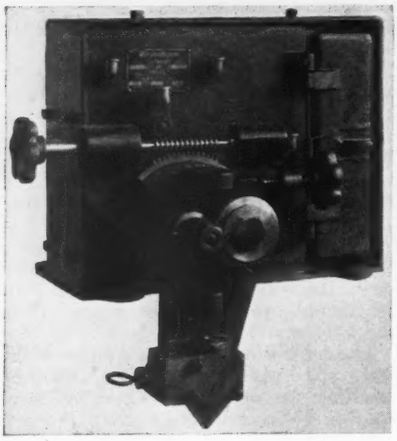
Automatic Arc Welder

A NEW machine designated as the Auto-Arc, for automatically feeding a continuous welding wire, used in metallic electrode welding, has been put on the market by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. This machine is suitable for feeding the wire to the work at any speed up to 3 ft. per minute, and it is claimed that it strikes the arc automatically and, if necessary, will exert a pull on the wire of approximately 200 lb. in order to prevent fusion of the electrode wire to the work.

The arc length can be adjusted so that it will be maintained at an average value of from 15 to 20 volts, and it is also claimed that the arc will remain almost constant at any given voltage. The ¼-hp. feed motor and the electromagnets do not obtain power from the arc circuit, and are therefore selected large enough to feed any size wire up to ⅜ in. in diameter. Certain parts of the machine are inclosed in a dirt-proof

housing, and all parts are said to be very accessible.

This automatic arc-welding equipment can be used to best advantage on work requiring the welding of long



Westinghouse Auto-Arc Welding Machine.

continuous seams, in production manufacturing operations, and also for some repair applications such as building up worn cross-heads, cross-head guides and valve guides for locomotives. It is also applied in building up worn flanges for yard locomotives and street railway car wheels.

Flood-Light

THE FL-300 flood-light unit shown here has recently been designed by the Pittsburgh Reflector Co., 304 Ross St., Pittsburgh, Pa., for mounting relatively close to the surface to be illuminated, approximately 10 to 20 ft. therefrom. It was designed particularly with a view to installation upon lighting standards at the curb in front of a building.

This light consists of a metal base, a semi-spherical metal casing, a cowl and focusing equipment, a reflector and cover with heat-resisting cover glass. The unit has a mogul socket carried on a focusing mechanism making possible movement of the lamp in all directions, which permits accurate focusing. The cover and casing are threaded so that the cover may be screwed on. Consequently, no hinges are necessary.

This light is designed for use with a 300-watt standard Mazda C lamp, but by the use of a socket reducer a 200-watt lamp may be used. An up-and-down focal adustment extends over a range of 2 in., in order to permit the use of the 200-watt lamp.

Ball-Bearing Worm-Gear Speed Reducers

ANNOUNCEMENT is made by Foote Bros. Gear & Machine Co., 236-246 North Curtis St., Chicago, Ill., of the development of a new line of high-efficiency worm-gear reduction units with ball or roller bearings, which are being marketed under the trade name of Hygrade Type HG worm-gear reducers.

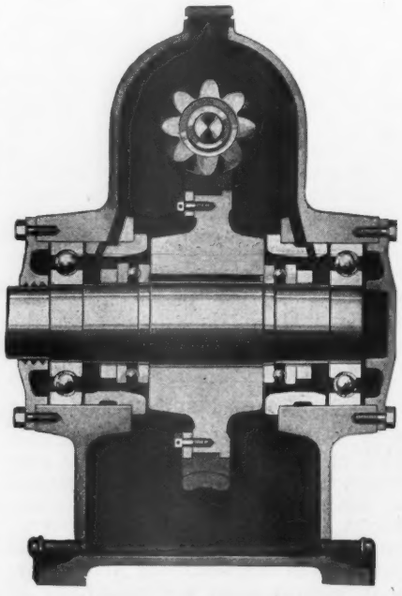
One of the important points, according to the manufacturer, is that all of the parts for the different types in which the line is made are interchangeable except for the cases. The Hygrade line comprises machines of the Type HGS with worm at the bottom, Type HGT with worm at the top, Type HGV with the worm shaft in a vertical position, and Type HGD, which is a double-reduction unit that permits the use of the very high ratios that are required in some installations.

All of these machines are supplied as standard with ball bearings and worm gear and worm gear shafts, for both radial and thrust load. The bearing mountings are shown in the two accompanying illustrations. The manufacturer is also prepared to furnish these units with radial roller bearings when specified, and in some cases with babbitted bronze bearings when these are preferred.

In the double-reduction unit, Type HGD, the high ratios of reduction, ranging from 50:1 to 10,000:1, are secured by the use of two worm-gear trains in series. The initial reduction is secured by a worm and gear of comparatively small size and pitch inclosed in a unit housing that can be bolted to the frame of a standard HGS, HGT or HGV reducer to provide for the larger reduction ratios.

It is well known that efficiencies of the ordinary worm reduction unit at ratios from 50:1 to 100:1 are quite low, and by using the double-reduction unit in such cases, a high average efficiency for the entire installation can be maintained.

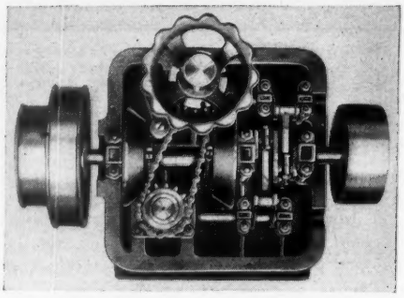
The addition of these units, the manufacturer states, completes the Foote IXL line, which includes spur, worm, and herringbone reduction units ranging in size from fractional horsepower up to 200 hp. in capacity, with a wide variation in the reduction ratios that can be obtained.



Foote Hygrade Type HG Worm Reduction Unit.

Variable-Speed Transmission

MARKETING of a mechanical variable-speed reducer has been announced by the Driscoll Transmission Corporation, 416 West 33d St., New York City. The manufacturer



Driscoll 1 - hp. Variable - Speed Transmission.

states that the transmission, when placed between any prime mover and the driven machine, will take the speed of the prime mover up to 1,750 r.p.m. and deliver any desired speed down to zero. The unit is rated at 1 hp. Changes in speed can be made without interruption of power, by means of a hand-wheel. All moving parts operate in a bath of oil in a dustproof case. The steel parts are heat-treated.

The description of the device, as given by the manufacturer, is as follows: No gears, belts, chains or friction disks are employed. Instead, the operation is by means of two variable-throw cranks that oscillate sleeves carrying quick-acting clutches. The other halves of the clutches are keyed to the driven member, which is rotated by the impulses transmitted through them. The clutches use rollers with double eccentrics to obtain quick locking and unlocking action. In the illustration, which shows an experimental model, the two driving clutch disks can be seen with the cranks and connecting rods between. In the improved commercial model, the clutches are mounted back to back.

1-Ton Electric Hoists

MARKETING of a new 1-ton electric hoist is announced by The Harrington Co., Seventeenth and Callowhill Sts., Philadelphia, Pa. The distinctive features of this hoist, as stated by the manufacturer, are its light weight, compactness, low headroom, and the universal method of mounting which permits its use in connection with hook or trolley. A 2½-hp. universal, series-wound motor drives the hoist.

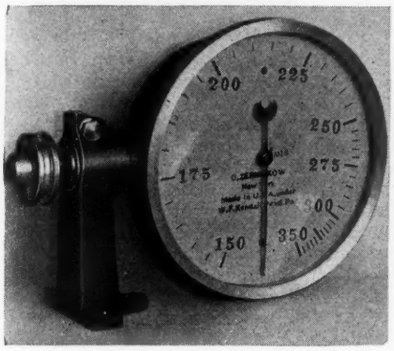
A load chain is used instead of a wire cable. This, according to the manufacturer, enables the hoist to make almost any lift without the use of a special drum, and also permits the hoist to pull loads in underneath it, which enables it to serve a larger floor area. The gear train consists of two pairs of spur gears and worm and worm wheels, all of which are enclosed in an oil-tight compartment. Ball bearings are used on the motor, worm and thrust.

Stationary Indicating Tachometers

ADDITION of a dial-indicating type of stationary tachometer to its line of O-Z instruments, is announced by O. Zernickow Co., 15 Park Row, New York, N. Y. The Model A stationary tachometer is shown in an accompanying illustration. The manufacturer states that these instruments are sensitive and accurate to within ½ of 1 per cent at any point of the scale. The operating principle is similar to the centrifugal pendulum construction as embodied in the O-Z hand tachometer.

Standard range is from 2 to 16 times the minimum speed either for r.p.m. or f.p.m. speeds. For example, 100 r.p.m. minimum speed and 200 r.p.m. maximum speed is a range of 1: 2; 100-1,600 r.p.m. is a range of 1: 16. Tachometers with higher ranges can be made to order.

These stationary tachometers have a 6-in. dial, are mounted on a bracket with a grooved driving pulley, and are designed for use wherever it is necessary to indicate operating speed. The pulley may be mounted at the right, left, top, or bottom of the dial. The



Zernickow Model A Stationary Tachometer

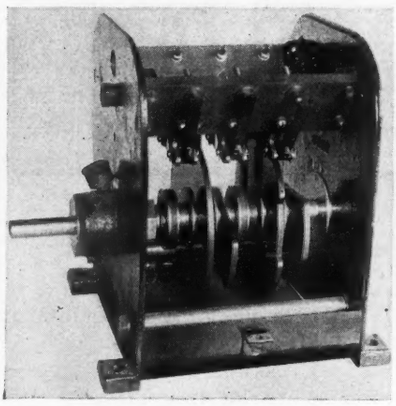
manufacturer recommends driving these tachometers by means of a spring belt. Other methods of drive may be arranged; for instance, direct-connected or flexible-shaft drive. This unit is made in two models. Model A, shown here, has the hand mounted in the center and a circular graduation over the entire circumference of the dial. It is recommended for normal conditions.

In Model B the hand is mounted below the center and the dial has semicircular graduations. This type, it is stated, is especially made to stand rough usage, where violent fluctuations or sudden starts and stops are encountered.

Rotating Cam Limit Switch

A ROTATING cam limit switch to be used with magnetic controllers for the automatic control of machines having a fixed sequence of operation and slowing down, stopping and reversing, has been announced by the Electric Controller & Manufacturing Co., Cleveland, Ohio.

This switch is totally inclosed, is equipped with tapered roller bearings



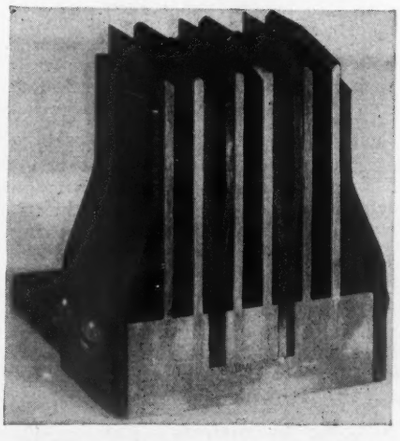
Rotating Cam Limit Switch Made by the Electric Controller & Manufacturing Co.

and is designed to carry up to six sets of contacts. Each of the cams that operate the opening and closing of the contacts is adjusted independently of the others.

Reinforced Switch Jaws

SWITCH jaws of a stronger type have been developed by the Reinforced Switch & Manufacturing Co., Pittsburgh, Pa. The accompanying illustration shows the general construction of the reinforced multiple switch jaw, although some of the details are not visible therein. Steel reinforcing is mounted between the several sets of jaws in such a manner that pressure is applied to the sides of the jaws, causing them to press firmly against the sides of the switch blade when the switch is closed, thus maintaining a uniform contact between jaws and blades, according to the manufacturer.

Both the switch jaw and the steel reinforcing springs are set in grooves cut in the block, and are held firmly in place by two ¼-in. pins that extend through the block. The ends of the holes through which the pins are driven are tapped and threaded for 14-20 screws. Between the contact surfaces where the steel springs would normally press upon the jaws, fiber insulation is inserted, so that the steel does not act as a conductor when the switch is closed. Pieces of Bakelite are used in the lower part of the outer switch jaws, and they act as a stop.

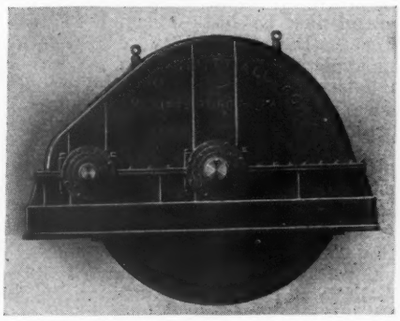


Type of Switch Jaws Developed by Reinforced Switch & Manufacturing Co.

Reduction Gear Units

THERE has just been developed and placed on the market by the R. D. Nuttall Co., Pittsburgh, Pa., the MS and MR series of reduction gear units for heavy service. In this series there are six units that range from 150- to 2,000-hp., rating and are designed for services that require the transmission of heavy loads at relatively high speed, such as on the main and auxiliary drives in steel mills, and in driving crushers, hoists, pumps, etc.

These units are equipped with either Nuttall 7½ deg. single helical or Nuttall herringbone gears, treated or untreated, depending on the application. They are furnished as desired with either sleeve or Timken tapered roller bearings. It is possible to replace one type of bearings with the other because the bearing housings are identical in both types. However, in case of a change of bearings new shafts would have to be provided.



Nuttall Series MS and MR Reduction Gear Units.

The gears are totally enclosed in a cast-iron case, the bottom of which serves as a reservoir for the lubricant. The gears run in a bath of oil, whereas the bearings are lubricated by a positive splash system. The same lubricant is used for both the gears and the bearings.

Time-Delay Attachment for Compensators

A NEW time-delay attachment, announced by the General Electric Company, is designed for use with hand-starting compensators to provide undervoltage protection during brief disturbances in industrial power circuits. It can readily be mounted in the same supporting holes as used for the standard undervoltage release. Time delay is accomplished by a falling solenoid plunger whose downward movement is retarded through a rack by a flywheel. Upward movement of the plunger disengages the rack from the flywheel pinion, permitting an instantaneous movement. The time delay is about one and a half seconds, and if power returns in less than that time, the starting compensator is not tripped.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Limit Stops—Bulletin 1037-B illustrates the type B limit stop for alternating- and direct-current motors, in connection with hoists on electric cranes, door hoists and other motor-driven equipment which must be automatically stopped after reaching a given point.—The Electric Controller & Mfg. Co., Cleveland, Ohio.

Gears—A booklet entitled "Ganschow Gears," gives an illustrated story of the origin and present organization of the William Ganschow Co., which is engaged in the production of industrial gears and worm and planetary speed transformers.—The William Ganschow Co., 18 N. Morgan St., Chicago, Ill.

Lead-Base Babbitt—Folder F 4474-A, discusses the use of and care to take in the application of Alloy No. 25 Westinghouse lead-base babbitt.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Unit Heaters—A 35-page catalog illustrates the Johnson Unit Heaters, shows their construction and method of installation and illustrates, graphically, the advantages claimed for their use.—Johnson Fan & Blower Co., 1319-1325 W. Lake St., Chicago, Ill.

Herringbone Speed Reducers—Catalog 100 covers the line of IXL continuous-tooth herringbone speed reducers which are made in capacities up to 150 hp. and reduction ratios up to 250:1.—Foote Bros. Gear & Machine Co., 220 N. Curtis St., Chicago, Ill.

Group Drives — A booklet entitled, "Group Drives More Economical for Most Drives," contains a reprint of an article by L. H. Hopkins, consulting transmission engineer, as well as the opinion of several eminent engineers.—Chas. A. Schieren Co., 37 Ferry St., New York, N. Y.

Coal and Ash Handling—Book 530 consists of a reprint of five articles which appeared in *Power* and were entitled, "Modern Methods in Coal and Ash Handling."—Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill.

Platforms—Catalog 684 covers a line of Truscon alloy-steel boxes and platforms for holding or handling materials by means of lift trucks, cranes, or other methods of handling. — Truscon Steel Co., Youngstown, Ohio.

Potheads—A circular illustrates the types of G & W potheads of the disconnecting, tapnut-terminal, non-disconnecting, and indoor-use-only types which are made in ten different shapes. A special cable support is shown which, it is said, is applicable to vertical or horizontal runs and does not scratch the cable or wear the sheath.—G & W Electric Specialty Co., 7780 Dante Ave., Chicago, Ill.

Wiring Devices—A 172-page catalog describes and illustrates the complete line of 4,000 wiring devices, together with the catalog numbers, a price list and a general index.—The Bryant Electric Co., Bridgeport, Conn.

Speed Reducer—A leaflet describes and illustrates a new type of speed reducer which employs a set of spur gears mounted on three shafts.—Palmer-Bee Co., Detroit, Mich.

Friction Clutches—The 70-page Catalog 17 describes the line of Falls friction clutches, which are manufactured by The Falls Clutch & Machinery Co., Cuyahoga Falls, Ohio. The entire Falls line of elevating, conveying and power transmission equipment is now a division of The Kent Machine Co., Kent, Ohio.

Air Filter — Bulletin 2223 discusses the Sirocco dry-plate air filter in which the air passes through a number of parallel plates in each filter section. Due to the staggered openings in the plates and the consequent reversal of direction of air, the dust loses its velocity and either builds up on the surface of the plate or falls to a retaining chamber in the bottom of the section.—American Blower Co., Detroit, Mich.

Automatic Compensators — Bulletin 1042-F describes and illustrates the E C & M automatic compensators for use with 110- to 550-volt a.c. squirrel-cage and synchronous motors.—The Electric Controller & Mfg. Co., Cleveland, Ohio.

Pneumatic Collecting and Conveying Systems — Catalog 291, third edition, devotes 72 pages to a description of pneumatic equipment, and contains a large amount of descriptive and engineering data.—B. F. Sturtevant Co., Hyde Park, Boston, Mass.

Ball Bearings—"The Dragon" is a monthly publication devoted to stories of Fafnir ball-bearing applications on various types of equipment used in different industries.—The Fafnir Bearing Co., New Britain, Conn.

Air Filter—A circular describes the new Midwest Self-Clean air filter which consists of an application of Midwest filters on an endless chain with a self-cleaning device.—Midwest Air Filters, Inc., Bradford, Pa.

Graphic Instruments — Catalog 406 devotes 70 pages to a discussion of the general and special features, as well as detailed specifications of the various types of Esterline-Angus graphic meters, accessories and supplies, as well as their inspection and instrument repairs. —The Esterline-Angus Co., Indianapolis, Ind.

Power Hand Saw—A circular describes and illustrates the application of a portable electric hand saw with universal motor, which, it is stated, will cut material up to 3-in. thickness. —Wappat Gear Works, Pittsburgh, Pa.

Oil Storage—A 60-page catalog illustrates applications of the various Bowser tank storage and distributing systems for lubricating oils, paint oils, and other liquids used around industrial plants.—S. F. Bowser & Co., Inc., Fort Wayne, Ind.

Portable Electric Tools—An 8-page circular illustrates the various Van Dorn portable electric tools, as well as floor and bench grinders.—The Van Dorn Electric Tool Co., Cleveland, Ohio.

Power Transmission Association Offers Prize for Emblem

THE Power Transmission Association has offered a prize of $250 for the best slogan emblem design for the association which is received on or before June 5, 1927. The American Society of Mechanical Engineers has been asked to name a committee of three to select the person or persons whose ideas are entitled to the award. The name of the winner will be announced at the National Industrial Advertisers Association convention in Cleveland, Ohio, June 15.

The wording should typify the objective of the association in the fewest possible words, with a striking action design, showing some application of or relation to *mechanical power transmission*. It is hoped to obtain an emblem or slogan insignia that can be used on all advertising or letters of the association or of any concern making equipment or materials used as mediums for the mechanical transmission of power. What is desired is something as effective and striking as "Save the Surface," or "Say It With Flowers" or similar emblems. Ideas are wanted: not necessarily a finished drawing.

The object of the Power Transmission Association is to determine and foster the right drive or use of mechanical power transmission for any given installation in any factory, shop, or place where power is used to drive machines. That is, the most efficient and economical use of mechanical power transmission mediums is sought. By mechanical power transmission mediums is meant belts and pulleys, shafting, gears, clutches, chains or any means of transmitting power mechanically.

This offer adds another to the long list of fine awards that are to be announced at the National Industrial Advertisers meeting in Cleveland to be held at the Hotel Statler, June 13-15.

Send your ideas, sketches and suggestions for this $250 award for its slogan emblem to the Power Transmission Association, Drexel Building, Philadelphia, Pa., on or before June 5.